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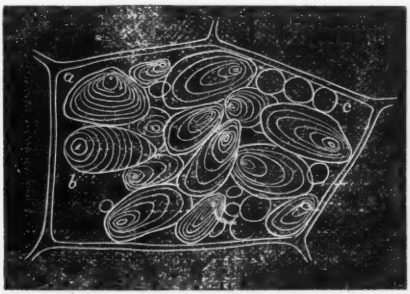
ABOUT STARCH.

BY PROF. M. W. HARRINGTON.

PERHAPS it would be more correct to have our title read "About Starches," for each species of the higher plants seems to have its own characteristic and recognizable sort of starch.

One of the most easily recognizable sorts of all is the starch from the potato. It is very easily got at, too, and requires little

Fig. 72.



or no preparation for its examination. Take a fresh potato and cutting it open, take the thinnest possible slice which one can make with a sharp razor. Deposit the slice on a glass-slip, drop a little water on it, cover it with a thin glass, and it is ready for examination.

Placing the specimen now under the microscope — a magnifying power of 250 diameters does very well — we see (Fig. 72) an im-

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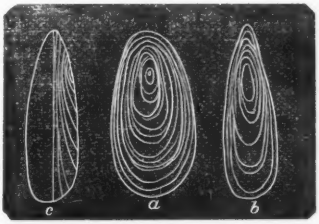
mense number of bodies of two sorts. The most striking are ovoid bodies of considerable apparent size, often showing a series of eccentric rings, the one within the other. Sometimes the rings are seen to be arranged about a dark point or nucleus. Mixed in with these ovoid bodies are large numbers of much smaller disk-shaped ones, without apparent rings. These two sorts of bodies are the starch granules of the potato. It is no unusual thing to find two pretty distinct sizes of starch grains in the same plant. There are intermediate forms of all sizes, but the two sizes referred to so much predominate as to strike the attention at once. The grains are packed in very closely together in much larger cells the cut edges of which can be distinguished, although they are very transparent. Here and there in the section are spots without starch grains and with much finer tissue. These are sections of the vascular bundles where longer and fibre-like cells and vessels which arise from the stem pass through the tuber. Toward the edge of the potato, too, the starch grains are seen to grow less numerous and the cells smaller with thicker walls.

To render the position of starch and cell-walls still more evident, let us apply a little of the aqueous solution of iodine to the specimen. This can be readily done by placing a drop at the edge of the thin glass cover. It will be gradually drawn under to mingle with the water. Meantime its progress and its effect can be watched with the eye at the microscope. Should the iodine not pass readily under the glass cover, its progress can be hastened by placing a bit of blotting paper in contact with the cover on the other side. As it absorbs the water, the iodine will pass in to supply its place. As the iodine comes in contact with the cell-walls they are stained a rich gold-color. At the same time, a series of changes is taking place in the starch. The grains were at first colorless and transparent; as the iodine reaches them, they are stained, first yellow, then red, violet, blue, and finally an opaque black blue, if the iodine is strong enough. Here we have the cell-walls colored one tint, and the starch another, and it is very easy to determine their relative positions.

The use of iodine is the most usual test for starch, and the resulting blue color is just as certain in the blue grains under the microscope as in the starch-paste in use by chemists. If sulphuric acid is added to the specimen, the cell-walls gradually turn blue too.

We have now the position, the general appearance and the usual test for starch. Let us examine it more carefully to see what its structure is. For this purpose take a very little matter scraped from the cut surface of the potato; aim to get only starch and none of the cell-structure. Place this on a clean glass slide, add a drop of water and put on a thin glass cover as before. By careful management of the light, we can probably now see the concentric rings quite plainly. They have the shape of the outline of the starch-grain. If it is egg-shaped, as is usually the case, so are they. If it is almost triangular or linear, as sometimes happens, so are the concentric rings. These rings are sometimes easily seen; at others, only considerable care can bring them out. I have sometimes found them plainer in the starch from a sprouting potato than from others. In potatoes frozen and thawed, they

Fig. 73.



appear distinct. If they can be brought out in no other way, the application of dilute chromic acid will usually show them very plainly. A few lines, scattered among the rest, are generally plainest.

Are these lines simple markings on the surface of the grains, or are they edges of layers one inside the other? In order to ascertain that we must roll them over and see how they look on the edge or on the other side. This is easily done. We have only to incline the body of the microscope a little more, and some of the grains will be carried down by the action of gravity, and will roll over with more or less freedom. If this does not serve, we can press on one edge of the thin cover with the point of a pencil, and a great commotion will be caused among the grains. As this subsides, we can watch some of them rolling over leisurely, now stopping for a moment on the face to give us an opportunity to examine that side, then rolling up on edge and hesitating there

while we survey that side too. Now if the lines are on the surface, a grain like *a* (fig. 73) would look like *b* when rolled up on its side. If, on the other hand, these rings mark the edges of concentric layers, coats arranged like the coats of an onion, they would be arranged in the edge view of the grain essentially as they are in the side view. As the grains roll over, we see very distinctly the rings are concentric yet; the starch grain must be composed of layers one over the other.

If we take a little of the starch from the potato and dry it, without the addition of water, at a temperature of perhaps 150°, we shall see a dark point appearing at one end — usually the smaller. This is the nucleus and around it are arranged the concentric rings already mentioned. It has been described as a little pedicle or stem by which the starch-grain is attached to the cell-wall. This was when it was still thought that the grains budded out from the wall, a theory completely disproven now, by what is known of the development and functions of the wall, as well as by specific observations on the formation of the grains themselves. The nuclei have been described too as holes, passing into the interior from the outside, and admitting the materials from which the successive layers were formed from without inwards. If the development of the starch-grain were endogenous, there might be some ground for this hole-theory of the nucleus, but it is now well proven that their formation is from within out, or exogenous. There is no easily accessible specimen at this season of the year, to illustrate this, but writers generally refer to ripening corn, where all the stages can sometimes be seen in a single grain. However, we can easily prove with the specimens under examination that the nucleus is neither a little stem nor a canal. If it were either, it would appear, as we roll the grains, sometimes elongated. As we roll the grains over, by inclination of the stage, or pressure from one side, as before, we see no difference in the shape of the nucleus. It is the same round or angular black spot, occupying the same position from whatever point it is viewed. If we are lucky, we may get a grain up on end, and examine it in the direction of its long diameter. The position of the nucleus and arrangement of the rings remain the same.

What can we conclude concerning the nature of the nucleus from this? It was indistinctly or not at all visible in the fresh grain; it becomes visible on drying, and looks like an air space.

It is in the structural centre of the grain. If the drying is carried far enough, cracks may be seen extending from the nucleus. They generally radiate, looking something like a star. Sometimes one long crack runs the greater part of the length of the grain. The cracks may and may not reach the surface. Taking all these facts together we can draw the fair conclusion; that the layers differ in density; that the inner layers are softer than the outer, because they contain successively more water; that the water is driven off by the heat and the consequent vacuity appears, forming the "nucleus," where there is most water, that is, in the innermost layers; that farther drying causes cracks to appear in the harder layers, the longer the drying the more extensive the cracks.

Further evidence in favor of this explanation of the starch-grain is afforded by the action of hot water and chemicals. If a little starch is boiled, the grains swell, burst and emit much glairy matter. At the same time a thin pellicle sinks to the bottom and is only gradually absorbed. These phenomena can be partially seen in a test-tube. They can be watched under the microscope if the observer has the apparatus for heating his slide without injuring his objectives. For those who are without this apparatus, perhaps the best way is to deposit a little starch with two or three drops of water on a glass slide, and then boil the water down without the application of too much heat. The slide should be allowed to cool before it is placed under the microscope. Starch can then be seen arrested in every stage of solution. One is apparently untouched; another is slightly swelled; another is much swelled at one end; still another is just ready to burst.

A similar series of phenomena can be seen by the application of caustic potash. Arrange a slide as before, for the application of iodine and treat in the same manner. The approach of the reagent causes a great commotion among the starch grains. They become uneasy, dance about, and finally sweep away to the other side of their limits. To see the action of the potash well, one must select a field easily accessible to the reagent, but where the exit of the grains is prevented by an air-bubble or bit of tissue just behind them. That being the case, the grains advise the observer of the approach of the potash by becoming very uneasy. As it strikes them they begin to swell, the swelling extending down their length as the potash advances. The swelling is mostly lateral, and what was an ovoid body before becomes a broad disk.

Meantime the grains warp and twist and writhe about. Separated before by considerable spaces, they now block up the whole field, and their outlines gradually disappear until the whole is a homogeneous mass.

The action of sulphuric acid differs a little. There is the same uneasiness of the grains on the approach of the acid. Meantime the concentric lines grow very sharp and distinct. When struck by the acid, the grains swell until nearly globular, then a fissure appears, generally in the vicinity of the nucleus. The grain is rent from side to side, and a mass of liquid matter with some grains intermixed, shoots out with so much force that it is sometimes carried to a distance of two or three times the diameter of the grain.

From these observations it appears evident: that the outer layers are more dense than the inner; that the semi-liquid interior absorbs water or other fluids by endosmose until the exterior is so much expanded as generally to burst; that the outer layers are much less readily dissolved than the inner.

The use of the polarizing apparatus shows in a striking and beautiful manner that the nucleus coincides with the optical centre of the grain — which might be translated that the layers are really regularly arranged around the nucleus. It also brings out more clearly the rings themselves. If abundance of light is used, and a plate of selenite is inserted between the object and the analyzer, a cross of colors of rare beauty is seen on the grains. If the polarizer is now rotated, the play of colors is very beautiful. The interesting fact to us, however, is that the arms of the color-cross meet at the nucleus.

We have thus seen that the starch grain is an organized body, composed of layers arranged about an eccentric focus, and that these layers increase in density from within out, the innermost being comparatively soft.

BOTANICAL OBSERVATIONS IN SOUTHERN UTAH.

BY C. C. PARRY.

No. 3.

When exposed to the withering summer heat of 105° to 110° F. in the valley of the Virgen, it was tantalizing to see within twenty miles to the north the rugged slopes of Pine Mountain streaked with patches of snow. Having secured most of the lowland and desert plants, I was anxious to supplement my collection with the alpine flora of the adjoining high mountain districts. Accordingly, on the 8th of June, I undertook an excursion to Pine valley, occupying an extensive basin on the northwest slope of Pine Mountain, thirty miles by the travelled road from St. George. Our route, which if practicable would have followed up the valley of the Santa Clara to its extreme sources, mounted by a series of very steep ascents to the abrupt sandstone ridges bounding the valley on the left. Higher up the rugged features of the bald uplands are greatly exaggerated by a confused intermingling of sedimentary and igneous rocks. Recent volcanic overflows had partly filled up the denuded sandstone ravines, with floods of black, scoriaceous lava. Some distance farther on the source of these igneous products is brought to view in two distinct volcanic cones, with clearly defined craters. The course of the Santa Clara through this confused labyrinth of aqueous and igneous deposits, is completely hid from view in inaccessible chasms. At a considerable elevation towards the foot-hills of Pine Mountain, there is a stretch of comparatively level country, scantily watered by irregular snow-fed streams, known as Damaran Valley. Here the polymorphous evergreen shrub oak (*Quercus undulata* Torr.) makes its appearance associated with the still more spiny-leaved Barberry (*Berberis Fremontii* Torr.). Occasionally in strongly impregnated saline soil, was noticed a broad leaved Lycium, the species of which, on account of the absence of flower or fruit, could not be satisfactorily determined.

Frequent along the roadside was an old Californian acquaintance, *Platystemon Californicum* Benth. (No. 8), not heretofore known east of the Sierra Nevada, and as if to keep up the distant

association there were occasionally extensive patches of *Emmenanthe penduliflora* Benth. (No. 175). In our noon halt under the shelter of a wagon-bed, it was quite refreshing to be able to gather an abundance of *Gilia filifolia* Nutt. (No. 195) and *Centrostegia Thurberi* Gray (No. 232), without necessary exposure to the hot sun. In crossing over the prolonged spurs of the mountain range to reach the northwestern slope of Pine mountain, we encounter a growth of clumpy cedars, in the shelter of which were found scattering plants of the *Frasera albo-marginata* Watson (No. 203) only known before from scanty specimens collected by Dr. Palmer in this same section in 1870. In similar gravelly stretches we also find *Caulanthus crassicaulis* Watson, *Physaria Newberryi* Gray, and *Thelesperma subsimplicifolium* Gray (No. 108). Quite conspicuous along the borders of rivulets and moist springy places, occurred the showy-flowered *Pentstemon Palmeri* Gray, lately extensively introduced into gardens from seed distributed by Mr. A. L. Siler.

Our upward route occasionally crossing the clear dashing stream of the Santa Clara along its upper course, finally emerged into the wide open basin of Pine valley, lying at the base of steep mountain ridges heavily timbered with pine and spruce. The regular outlines of this basin at once indicate it as the bed of an ancient lake, since drained through the deep gash through which the Santa Clara courses to mingle its tribute of melting snow with the turbid waters of the Virgen. The atmospheric coolness of this elevated district afforded a refreshing contrast with the torrid heat of the lowlands, and was especially noticeable in the vegetation, which exhibited a more northern aspect. In the cultivated fields the difference was equally striking; wheat then ready for harvest at the mouth of the Santa Clara, was just spreading out its early leaves at its upper sources; cotton-woods which several weeks before had opened their bolls in St. George, were barely in bud at Pine valley. In fact the flowering season in these elevated districts was only just commenced, and the bald alpine ridges toward the summit of the range showed no signs of advancing vegetation, being still occupied by scattered snow drifts. Under these circumstances only the lower slopes afforded scope for botanizing during the short stay devoted to this section.

Disagreeably abundant in all the foot-hills, as a serious impediment to comfortable travelling, is the deciduous leaved shrub oak

(*Quercus undulata* Torr. var. *Gunnisoni* Engel. ined.). Much more attractive with its glossy foliage and long feathery seeds, is the mountain mahogany, *Cercocarpus ledifolius* Nutt. (No. 58), which here attains the dimensions of a small tree often twenty feet in height, with trunks six to eight inches in diameter. Along the borders of all the numerous mountain streams the common alder (*Alnus incana* var. *glauca*) is abundant, associated as elsewhere in the Rocky Mountain districts with *Betula occidentalis* Hook. As if to complete on a small scale the resemblance with analogous eastern sections, the western sugar maple (*Acer grandidentatum* Nutt.) makes its appearance. Though generally of a low, bushy growth, it occasionally attains the size of a small tree, with trunks a foot or more in diameter. The wood in hand specimens is undistinguishable from our hard maple, and is applied to similar uses. The Coniferæ of this section include, on the lower slopes extending down into the valley, large trees of *Pinus ponderosa* and *Abies Douglasii*, succeeded higher up by scattering growths of *Pinus flexilis* and *Abies concolor*, and towards the summit by dense forests of *Abies Engelmanni*. The highest elevation is at no point sufficient to show a well-defined timber line, though bare alpine patches are spread out at various exposed points near the summit of the range. The lower dividing ridge to the north and west is mainly occupied by a scattering growth of cedar, the undergrowth affording the following plants, viz.: *Physaria Newberryi* Gray (No. 14), *Pachystima myrsinites* Raf., *Astragalus atratus* Watson (No. 47), *Hymenopappus luteus* Nutt. (No. 107), *Gilia aggregata* var. *Bridgesii* (No. 194), *Echinospermum deflexum* Lehn. (No. 172).

In the upper portion of the main valley was found a very neat species of Trifolium with large reflexed heads, *Trifolium Bolanderi* Gray (No. 34). Near by on the borders of a springy bog occurred in great abundance the interesting *Lewisia Brachycalyx* Engel. (No. 22). This rare species, only known heretofore by a few imperfect fragments, will be characterized anew by Dr. Engelmann in the accompanying list. Though much inferior in beauty to the northern typical species (*Lewisia rediviva* Ph.), it still presents the same style of flower and foliage on a somewhat smaller scale, and being undoubtedly hardy, may be improved by cultivation. Some of the more familiar aspects of the sub-alpine flora were presented in the well known Rocky Mountain forms of *Aqui-*

legia cærulea Torr., *Mertensia sibirica* Don., and *Polemonium humile* Willd. It would have been interesting later in the season to have made a more thorough examination of the high alpine exposures, which from their isolated position would doubtless afford rare or new species. The exchange from the cool snow-drifts of Pine mountain to the oven heat of St. George proved much less pleasant than the reverse process, though more easily accomplished. It is worthy of remark in this connection to note the mutual dependence of these two strongly contrasted but adjoining districts. Thus the moisture, condensed either in the form of summer rain or winter snow on these high mountain ridges, is not all exposed in open water courses to be directly returned to the atmosphere by the intense evaporation of the lower desert tracts. A large part of it sinks into the pervious sandstone strata, dipping towards the south, thence working its way through deep unseen channels, it breaks out in the form of copious springs at the base of the high cliffs bounding the Valley of the Virgen. From this source is derived the necessary supplies of irrigating water for the gardens of Washington and St. George. In return, these semi-tropical districts contribute to the dwellers in the mountains the elaborated products of the choicest garden fruits that would be otherwise unattainable. Without such a mutual exchange neither of these sections would be as well adapted as now for civilized habitation.

On the 25th of June having completed my botanical collection in the valley of the Virgen, I left on my return route to Salt Lake, having arranged to spend a few weeks in the more elevated districts within the rim of the great basin.

On reaching Cedar city, sixty miles to the north of St. George, in the latter part of June, it was not very encouraging to note that the continued dry season had in a great measure completed the development of the early Spring plants, which were but scantily succeeded by later summer forms. On the rocky and variegated marly exposures adjoining the town, the conditions seemed especially favorable for a peculiar flora, and this expectation was in a measure realized, though in scanty forms. Among these is a well marked new species of Gaillardia characterized by Prof. Gray as *Gaillardia acaulis* n. sp. (No 120).

Here also occurred quite abundantly a species of *Lepidium* near to *Lepidium integrifolium* Nutt., or possibly a new species (No. 16).

Other rarities include *Polygala subspinosa* Watson (No. 32), *Brickellia linifolia* D. C. Eaton (No. 89) and *Eriogonum villiflorum* Gray (No. 243). On one of the exposed rocky slopes was gathered a dwarfed variety of *Cercocarpus ledifolius* Nutt., or possibly a new species to which the name of *Cercocarpus intricatus* n. sp. (No. 59) may be provisionally applied. Along the gravelly margins of Cedar Creek was found *Astragalus Sonoræ* Gray (No. 53), *Astragalus longocarpus* Gray (No. 52) *Thelesperma subnudum* Gray, n. sp. (No. 109) and *Lygodesmia grandiflora* Gray (No. 128). On shaded hill-sides, *Cercocarpus ledifolius* Nutt., *Cowania Mexicana* Don. and *Fraxinus anomala* Torr. (No. 210), are abundant. Having soon exhausted this scanty flora, my attention was directed to the high mountain range of the Wahsatch, rising abruptly to the East, and overlooking the southern extension of the great interior basin. An ascent of about 3,000 feet in a distance of three miles, brings us to the outer crest of the range, which extends eastward in an irregular series of undulations to the upper Sevier valley. At several points on the lee side of steep ridges there were still the remains of rapidly wasting snow banks. Notwithstanding the comparative elevation and freshness of vegetation, there was a scant supply of surface water except immediately adjoining large snow banks. The prevalent timber growth was made up of interrupted groves of Aspen poplar, some high ridges in the distance showing a few scattered pines and spruces. Four miles back towards the interior of the range, the country expands into wide grassy slopes, and frequent springs and running streams bordered by snow drifts, give unwonted freshness to the pastoral scenery. Here is located the summer sheep range, and dairy farms of this district, of which the only apparent drawback to their attractive and productive features, is the annoying prevalence of blood-thirsty flies.

The botanical features are very similar to other elevated pastoral districts in the interior West. Senecios and Arnicas serve to give a yellow cast to the open grassy meadows; shades of blue are supplied by thrifty Delphiniums. In the aspen copses there is a dense undergrowth made up mainly of Prunus, Rosa, Symphoricarpus, and Salix. Less conspicuous but more interesting as peculiar to the flora of this district may be noted *Calandrina pygmæa* Gray, *Trifolium eriocephalum* Gray (No. 35), *Oxytrophis campestris* var.? and *Cordylanthus Kingii* Watson (No. 156).

The destructive effects of exclusive sheep grazing on the native forage grasses, was manifest in a disagreeable prevalence of the common yarrow (*Achillea millefolium* L.), wherever the herds had been long stationed. On other hill slopes the entire vegetation was usurped by a bushy perennial umbelliferous plant. *Ligusticum Scopulorum* Gray (No. 82), which alone seemed capable of withstanding the destructive effects of close grazing; possibly its protection is due to some nauseous quality serving to keep the sheep herds at a distance.

On account of the severity of the weather, and the great depth of winter snow, this mountain section is abandoned in the winter for the warmer, though less productive sage-brush lowlands. No attempt has yet been made to establish permanent settlements here for the cultivation of the rich soil, though apparently admirably fitted for the growth of the hardier small grains and root crops.

After spending a few days very pleasantly in the rude homes of these hospitable herders, I returned to Cedar city, by a very direct trail, leading down the steepest part of the mountain slope. On this route I was fortunate in securing good fruiting specimens of *Astragalus megacarpus* Gray (No. 51), hitherto only known from Nuttall's original specimens.

On this same trip my attention was particularly directed to the two species of Rocky mountain balsam, *Abies grandis* Lindl., and *Abies concolor* Engel. ined.; in regard to which so much needless confusion has arisen. I here found the two species growing not far distant from one another, and exhibiting plainly their distinctive characters (as *trees* if not as herbarium specimens). Thus we may note *Abies grandis* with a more strict habit, narrower leaves, smooth bark (at all sizes) and deep purple cones, more exclusively confined to high elevations. *Per contra; Abies concolor*, less pyramidal in shape, with much broader leaves, rough furrowed bark (in old trees) and apple-green cylindrical cones, found growing at much lower elevations on the mountain slope, and less exclusively confined to moist ground. It is to be hoped that this latter species may soon be introduced into cultivation when its ornamental qualities can be more fully developed. Succeeding my return from the mountain range summer rains set in with unusual frequency and copiousness. Dark thunder clouds hovering about the distant mountains to the east which they illuminated with the

most brilliant electrical discharges, were the sure precursors of floods sweeping down the rocky bed of Cedar creek. The particular location of each storm was plainly indicated by the different colored mud, brought down on the swollen flood, varying from dark brown to dirty yellow or dull red. The stratified deposits thus spread over the bed of the great basin made up the permanent geological record of summer storms in the Wahsatch in 1874.

On the 20th of July I took final leave of this section of southern Utah, carrying with me many pleasant remembrances of the kindness and hospitality received from this much misrepresented Mormon people, who in supplanting the digger Indians by civilized homes of industry and refinement, are deserving of more credit than they have yet received.

The list of plants following will conclude the present paper.

THE INDIAN CEMETERY OF THE GRUTA DAS MUMIAS, SOUTHERN MINAS GERAES, BRAZIL.

BY PROF. CH. FRED. HARTT.

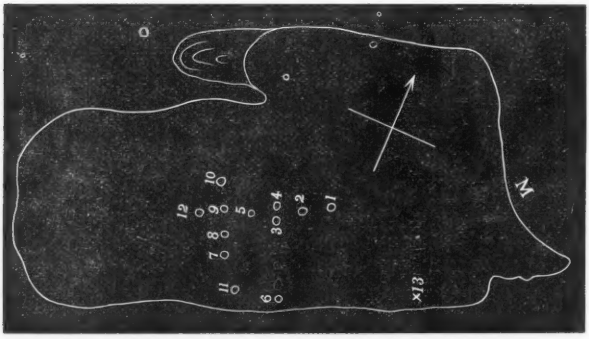
THE Fazenda da Fortaleza, also known as Santa Anna, formerly the property of the late Barão de Lage, and probably the finest plantation in Brazil, is situated in the southern part of the province of Minas Geraes at a distance of about seventeen miles to the east of the city of Juiz de Fora.[1] It belongs to-day to the Conselheiro Diogo Velho C. de Albuquergue, a gentlemen celebrated as a politician, and who occupies the important post of President of the União Industria road. The region in which the Fazenda is situated is composed of gneiss, similar to that of the Serra do Mar, and of the vicinity of Rio de Janeiro, and probably of Archæan age.

At a distance of a league, more or less, to the south or southeast of the Fazenda, is a line of high hills of the same gneiss, three of which form prominent heads presenting lofty, almost perpendicular precipices, smooth and rounded and striped vertically with black bands, like the cliffs of the neighborhood of Rio de Ja-

[1] A charming description of this fazenda will be found in Madam Agassiz's "Journey in Brazil."

neiro. The easternmost of these hills, a peak probably not far from three thousand feet in height above the sea, with magnificent, nearly vertical precipices, is called the Fortaleza or the Fortress, and gives its name to the Fazenda. The second hill is lower and less prominent, but towards the northward, in its upper part, it presents a fine rounded, precipitous front, in the solid rock of which are excavated three grottos, one of which, used anciently as a burial place by the Indians, forms the subject of this paper. As this hill has, so far as I have been able to learn, no distinctive ap-

Fig. 71.



Ground plan of Gruta das Mumias showing Interments.

1. Body of child, in basket.
2. Mummied bodies of woman and child.
3. Skeleton wrapped in bast.
4. " " "
5. Remains of child buried in pot.
6. " " " wrapped in hammock.
7, 8, 9. 10. Four pots containing skeletons.
11. Mummied bodies of mother and child buried in the same hammock.
12. Body of little child wrapped in bast and palm straw.
13. Locality where arrow was found.
The compass bears N. magnetic.

pellation, I have taken the liberty to name it after my distinguished friend the proprietor of the Fazenda, calling it the Morro de Diogo Velho. The third mountain is a fine dome about two thousand feet in height, known as the Morro da Babylonia, from whose top a magnificent view of the country to the northward is to be obtained.

In the two last-named hills the beds of gneiss dip to the south-southeastward at an angle of about 40°.

The largest of the caverns, known as the Gruta das Mumias, is situated near the base of a precipice on the northeastern side of

the Morro de Diogo Velho, and at a height of about seven hundred feet above the level of the Fazenda. It consists of an irregular excavation which penetrates the hill in a direction S. 60° W. (mag.) its axis being considerably inclined so that from the mouth to the end of the cave, the floor offers an ascent.

The roof and sides of the cavern form together an arch whose curves are sometimes quite regular. In various parts of the grotto there are in the sides and roof more or less deep, rounded excavations that penetrate the rock in various directions, much resembling potholes, but which are, however, not due to the action of water. On the eastern side of the cavern is one of these excavations which is extending itself in a direction parallel to the axis of the cavern, but has not yet reached the same depth. It is separated from the main hall by a narrow wall of rock which is gradually breaking down and disappearing. Originally, probably, this wall extended farther toward the mouth of the cavern.

The floor of the cave before being disturbed by the work of exploration consisted of a bed of fragments of rock, fallen from the roof and sides, and mingled with earth derived from the decomposition of the gneiss, from the dung of jaguars, bats and other animals, and from the destruction of the enormous clay nests of a large species of bee, which inhabits the cave, building on the roof. When the cavern was discovered the floor was strewn with fragments of these nests, sometimes three feet or more in diameter.

The cavern measures approximately seventy-five feet in length, twenty-five in breadth at the mouth, forty-two feet in greatest breadth and twelve feet more or less in height. The gneiss in which it is excavated consists of distinct, thin, alternating bands of which some are made up principally of a very black mica in small crystals. Others are, for the most part, composed of little grains of silica with but little feldspar, while yet others consist of a mixture of quartz and feldspar rather coarsely crystallized. It is noteworthy that the rock contains no garnets. The beds are inclined to the south-southeastward at an angle of 40°–45°±, and are full of small, but sharp plications, which, together with the alternation of the white and black bands, give to the rock, as clearly exposed on the sides and roof of the cavern, an exceedingly beautiful appearance. The second cavern is in this respect perhaps even more noteworthy than the first.

Examining the surface of the rock in the interior of the grottos it will be seen that the gneiss is suffering a very rapid decomposition, and is scaling off in thin flakes, which are sometimes so soft as to break up readily between the fingers.

As the gneiss is very compact and had originally but few fractures, and as the decomposition progresses from the outside inwards, the rock of course decomposes concentrically, giving rise to more or less regular, concave surfaces. The surface of the rock inside the cavern is constantly damp, but not sufficiently wet to drip. I suppose that this dampness is for the greater part caused by the soaking through the solid rock of water from above, and that the decomposition is caused mainly by the action of carbonic acid derived from the air.

Large caverns like that just described are rarely encountered in the gneiss of Brazil, but small ones abound and may be seen in the precipices of the gneiss hills of the vicinity of Rio.

It is somewhat difficult to determine just how the caverns of the Morro de Diogo Velho at first originated, but it is very likely that they commenced by the decomposition of an isolated mass in the gneiss, that had a somewhat different mineralogical composition than that of the rest of the rock. Ordinarily, cavities of this kind soon disappear from the surface of a cliff, because of the scaling off of the thick, half decomposed sheet, which falls from time to time, leaving a new surface exposed. It is not at all astonishing that the decomposition should go on irregularly and that the cavity should enlarge itself in some parts more rapidly than in others, giving rise to the pot-hole-like excavations above described. A very slight difference in the hardness of the rock, or in the amount of moisture, would be sufficient to determine the more rapid decomposition of a certain part of the surface, giving rise to a hollow. On the Rio Tapajos the edges of the beds of coal-measure limestone, exposed to the action of the waters of the Igarapé de Bomjardim, during the rainy season, are not dissolved away evenly, but are honeycombed with grottos. Witness also the way in which metals and other substances are honeycombed by acids.

The upper grottos of the Morro de Diogo Velho are like the lower caverns, but smaller. I shall not describe them particularly, because archæologically they do not appear to be of interest,

since they have afforded no human remains. All the caverns, contrary to the opinion of many, are natural excavations, and offer no signs of being, even in part, the work of man.

The lower and larger cavern is perfectly visible from the lowlands to the north, but as it is quite difficult of access, it does not appear to have been visited by civilized persons until, in 1871, Sr. Antunes, the administrator of the plantation, succeeded with much difficulty in reaching it. He, however, saw nothing of the archæological treasures it contained, and their discovery remained to be made by Dr. Manoel Bazilio Furtado, a gentleman, who, much interested in the study of antiquities, has already made explorations of a sepulchral cavern, and of a rock shelter on the head waters of the Rio Itapémerim, an account of which he has promised to furnish me.

As soon as Dr. Bazilio knew of the existence of the caverns of the Morro de Diogo Velho, he visited and examined them, finding human remains in the larger one, thus proving it to be an ancient Indian burial-place. Several other visits were made to the cave, not only by Dr. Bazilio, but also by the Conselheiro Diogo Velho, and by Dr. Rozendo Muniz. About three months ago, Sr. Diogo Velho invited Dr. Ladisláu Netto, the well-known Director of the Museu Nacional of Rio, to visit and examine the locality, and to facilitate the exploration he caused roads to be cut and steps and ladders to be constructed.

Dr. Netto had the kindness to invite me to accompany him, and was so good as to delay the excursion until I could find time to go with him. On the 6th of December, we left Rio in company with Sr. Albuquerque, one of the assistants of the Museum, and M. Glaziou, the Director of the Passeio Publico of Rio, and a man who has probably done more than any one else in the way of actual botanical exploration in Brazil. As my task in this paper is simply to give an account of the scientific results of our explorations, I shall attempt no description of our most interesting journey to the Fazenda of Fortaleza, and I shall be obliged to limit myself to saying that we were overwhelmed with kindnesses and attentions by the hospitable Conselheiro and his friends. Dr. Diogo Velho placed at the disposition of Dr. Netto more than twenty slaves, under the superintendence of Sr. Antunes, and, accompanied by his associates Dr. Machado and Dr. Bazilio, he assisted us personally in the work of exploration.

In the following paper I will give not only the results of my own personal observations, but also the facts relating to the previous explorations, which were furnished me by Dr. Bazilio and Sr. Antunes, and of which my notes were written in the cavern with the greatest care, being afterwards revised by these gentlemen. Dr. Netto has very kindly permitted me to examine the objects sent to the Museu Nacional, so that in this paper I shall be able to give a very complete account of the interments found in it. A detailed description of the human remains themselves I am obliged to defer to another occasion.

As the preliminary excavations in different parts of the cavern offered us no results, we found it necessary to proceed more systematically. We first of all threw out all the large stone and rock masses that encumbered the cavern, amounting to many tons. A line of negroes was then formed across the mouth of the cavern, and the loose earth was examined to a considerable depth from one end of the cave to the other, the work occupying the greater part of two days.

On the first day nothing was found, but very early on the next morning two interments were discovered, one of a child buried in an earthen pot, the other of a young person wrapped up in a hammock, and shortly afterwards there was found the body of a little child enveloped in bast and palm straw. This was the last object discovered.

The following plan (Fig. 74) represents the floor of the cavern and the localities of the various interments, which are numbered as in the following description.

No. 1. Body of a child buried in a well-woven little basket, above which were laid several pieces of bark. Found by Sr. Antunes.

No. 2. Mummied body of a woman with a little child in her arms. These remains were sent to the Museu Nacional, but have not yet been received, so that I cannot describe them.

No. 3. Skeleton wrapped up in bast, but concerning which I could obtain no certain information.

No. 4. Skeleton of a man (?) found wrapped up in bast and afterward in palm straw. It was found sometime before our visit, and had been unwrapped, the bones having, however, been left in the cave. The skull is remarkable for a perforation near the crown, apparently the result of a wound. The remains were to

be sent to the Museum, but not having arrived at time of writing, I have not been able to examine them closely.

No. 5. Bones of a child buried in an earthen vessel, and discovered during our exploration.

The upper part of the *ygaçába* was wanting, together with a large part of the bones, including the skull, and the remaining parts of the vessel were broken, the fragments however remaining *in situ*. The pot was ovoidal in shape, the lower part resembling the tapering end of an egg. It was not at all flattened, and consequently the vessel could be kept upright only by being set in the ground or supported in some way. The material of which it was constructed was clay mixed with somewhat coarse sand. The vessel appears to have been made over a mould; indeed it would have been difficult to build it up in any other way. The inside is slightly rough, showing no signs of having been smoothed by a finishing tool, whose marks are however clearly observable on the outside surface. No signs of paint, of varnish, or of decoration of any kind, were observed on the parts of the vessel preserved.

The burning was incomplete, and for about one-third of the thickness from each surface, the clay of the walls is well reddened, the interior remaining of a grayish color. In the pot were found the following bones belonging to the skeleton of a young person: —The femur, tibia and fibula of one leg, united by the dried ligaments and with parts of the muscles preserved, the knee being flexed, showing that probably the body was buried with the knees doubled up against the breast. There were also the united bones of a fore arm, a scapula, a hand, six dorsal vertebræ, four ribs of the left side united, and in addition six ribs, separated. The rest of the bones were wanting, and I doubt whether they existed in the vessel when it was found by the negroes, for I searched carefully in the earth thrown from the spot, but could find nothing. It seems therefore probable that at some previous time the grave had been disturbed, perhaps by some wild beast. The bones were found mingled with a light earth which appeared to be mainly composed of organic matter, and to be full of the skins of the larvæ of the insects that attacked the body.

In the same earth were also found a number of seeds, which M. Glaziou identified as belonging to a species of *Anona* or custard apple. There were also found numerous fragments of the pinnules

of a species of palm which the same botanist recognized as *Geonoma pinnatifida*. It is probable that the body was wrapped in this palm straw before being deposited in the *ygaçába*. The fragments of the vessel and the bones were destined for the Museu Nacional.

No. 6. Remains of a child from seven to ten years of age, found wrapped in a hammock, and discovered on the second day of our exploration. I assisted in their disinterment, and examined attentively their disposition in the grave.

The body, which is now in part reduced to the state of a mummy, was doubled up with the knees against the breast, and then wound about with the hammock, having exposed the upper part of the head and the feet which last protruded through the hammock. The bundle when found was oval and flattened, and about two feet long. The head was turned toward the left and the body, perhaps owing to the pressure of the superincumbent earth, rested on the left side. The feet were directed towards the mouth of the cavern. The grave was not more than eighteen inches or two feet deep.

The soft parts of the body had for the most part disappeared, but there still remained a part of the scalp with a few hairs and the skin of the trunk which was dry like parchment.

I have not yet been able to examine carefully the hammock, but it appears to be constructed like that which was found wrapped about the woman in the interment No. 11. It is however made of the fibres of a palm, *Astrocaryum tucum*, and not of cotton.

Underneath the hammock adhered what seemed to be fragments of large leaves, that had been laid in the bottom of the grave before the body was deposited. By the side of the hammock there were also found fragments of palm straw, which made me suspect that outside of the hammock was a wrapping of this material. Above the body in the grave, were found a few little sticks which were disarranged in digging. The body was covered simply with earth and stones. The body, still wrapped in the hammock, will be preserved in the Museu Nacional.

Nos. 7, 8, 9, 10. Four *ygaçábas* buried in a line transverse to the grotto. They were extracted before our exploration, and are said to have been sent to the private museum of His Majesty the Emperor, but they have not yet arrived there. The fourth, No. 10, was broken in extraction, and I saw fragments in the hands of Sr. Antunes at the Fazenda. Dr. Bazilio has furnished me with some important notes on each of the four interments.

The *ygaçábas* were all ovoidal in form, without base, and were buried upright. The mouth of each was closed by a round, thick piece of the bark of the *Jequitibá*, set into the orifice. Outside, the urns were covered with a sort of basket-work of the bast of the *Embaúba tinga*, a species of Cecropia, and to this was attached a cord extending across the mouth to serve as a handle, the shape of the *ygaçábas* rendering it necessary to provide means of this kind for their conduction. It is worthy of note that all the urns are small and contain only the bones of children.

Over the mouth of No. 8 was found a small basket a little more than eight inches in diameter and made of *cipó tinga* a kind of lliana, which had been split, carefully prepared and woven in an open manner, the basket being furnished with a cord across the mouth, to serve as a handle. It contained a number of little bundles of palm straw, similar to those that form the outside covering of the body in No. 12. The basket was crushed flat by the weight of the earth and stones. By the side of the same *ygaçába* was found interred a bundle of five sticks, bound near each end by a bit of *cipó*. These sticks were of about the thickness of a finger and four were about three feet in length, the fifth was somewhat shorter. They were all sharp at one extremity and blunt and polished at the other. My friend Dr. Muniz Barretto, who was present when the pot was found, tells me that it contained the skeleton of a child wrapped up in bast and palm straw, forming a bundle which was afterward tied up with a cord of the palm fibre.

By the side of No. 9, and in part bent over the mouth of the pot, was found a "bornal de caça" or a sort of small haversack, woven in an open manner of palm fibre thread, and furnished with a long cord by which it might be carried like a game bag. According to the description of Dr. Bazilio this "bornal" was of exactly the same shape as the sacks used at present, not only by the Botocudos but also by many other Indian tribes of Brazil. The sack was full of little bundles of palm straw, similar to those found in the basket accompanying No. 8.

The *ygaçába*, No. 10, broken in extraction, contained the bones of a child of about twelve years of age and which had already finished its first dentition. The vessel of which Sr. Antunes showed me fragments, was of the form of an egg truncated at the larger end. The mouth was large and entirely without lip. The

interior of the vessel showed the casts of striæ on the mould. The exterior surface was moderately well worked down, showing, however, long, hard marks of the finishing tool. There were no signs either of ornament or of glazing.

The four *ygaçábas* were separated one from the other by little sticks, which circumstance makes me suspect that they were all deposited together.

On the surface of the ground near the pots, but in a position which I am unable to indicate on the plan, was found the body of a child probably wrapped up in bast.

No. 11. Mummied bodies of a mother and new-born child, wrapped in the same hammock. These most interesting specimens are preserved in the Museu Nacional where I have had an opportunity of examining them. The body of the woman is a natural mummy, simply preserved in a half decomposed and dry state. The skin remains on nearly the whole body, and, so perfect is the state of preservation, that the lower lip remains, and the feet are simply shrivelled up. The body reclines somewhat on the left side. The head is turned to the left. The left hand was placed on the breast and the right was held just above the abdomen. The legs, partially drawn up, are bent over to the left. The body bears no ornament.

By the left side of the corpse was found a little bundle containing the dried-up, natural mummy of a new-born babe, much doubled up and wrinkled and but little discolored. The skin is well preserved. The left arm bears a sort of band of woven string, and on one leg is a string of beads made of rather wide sections of a hollow bone strung on a coarse thread, a touching evidence of tenderness. The body was wrapped up in bast, and tied outside with a coarse string which passed through the fingers of the right hand of the woman, who in death was thus closely united to her offspring. It is very probable that the woman died in childbirth, but this is a question in medical jurisprudence which I am not competent to decide. Both mother and child were buried in the same hammock, which is in a fair state of preservation and accompanies the body in the museum, but, as it has been removed from the mummies, it is not possible to determine the manner in which it was wound about them. The hammock consists of rather coarse cotton thread, and is constructed like that in which the body of the young person, No. 6, is en-

wrapped. It consists of threads parallel to one another and considerably spaced, united together at intervals of a foot or more by transverse threads. At the two extremities of the hammock, the threads appear to be simply gathered together for the attachment of a stout cord for suspension.

In the manner of weaving, or rather in the arrangement of the threads, the hammocks of the cavern of the Morro de Diogo Velho bear a close resemblance to that represented in one of Lery's woodcuts,[2] but the form is different. Lery says that the Brazilian Indians made their *inís* of cotton thread, sometimes like a net, sometimes woven into a close cloth. Both Lery and Stade call the hammock *iní* or *inní*, a word which I have sought in vain in Tupí dictionaries, and which does not occur to-day in Lingoa geral.

On the Amazonas the name for hammock is *kyçána* (*kyçába*, old Tupí), a word which seems to have been derived from ker dormir (to sleep) and the termination *çábá* or *çána*, which indicates the instrument with which anything is done. In the language of the Mundurucus I have found *ŭlu* and in that of the Maués *yly* meaning hammock, both of which forms may well have been derived from the same source as *iní*, as the three languages above enumerated belong to the same family.

Underneath the bundle formed by the two bodies were laid side by side a number of broad strips of coarse bark.

Over the bodies was deposited upside down a basket, well made and full of little bundles of palm straw, each with a knot. Over this were laid side by side strips of coarse bark, like those underneath the body, the whole being covered with earth.

In the same grave was found a "bornal" similar to that already described, but in a bad state of preservation.

No. 12. Bundle containing the remains of a little child, found buried at a slight depth and extracted in my presence. The body was well wrapped in the first place in strips of bast forming a little bundle scarcely eighteen inches long, a foot and a half broad and about four inches high. This package was then loosely covered on the outside with palm straw, which was tied up in a number of little bundles like those found in the baskets, and the "bornal" already described. The body was deposited immediately upon a flat stone, and over it were placed, side by side, four flat pieces of bark, about two feet long and two inches wide, forming a sort of

[1] Lery, Historia Navigationis in Brasiliam, edition 1586, p. 252.

protecting covering. The bast, palm straw, and bark are all well preserved but the package has not been opened.

I examined the cavern carefully everywhere for objects of stone, fireplaces, etc., but found no sign that it had ever been either a dwelling or that it was a place much resorted to. Sr. Antunes found on the floor of the cavern a fire brand and a long split stick which he thought might have been used to collect water, but both these objects may be very recent. In the spot marked 13 a sharpened stick was found buried. I have not seen it, but Dr. Bazilio thought it to be an arrow.

The observations made in the Gruta das Mumias show that the cavern is a natural excavation which has served as a cemetery to savage Indians. So far as the mode of burial and the preservation of the bodies are concerned it offers nothing very novel, but as an archæological locality carefully explored it is of much importance.

The Gruta das Mumias is not the only cave in Brazil in which Indian interments have been found. Dr. Bazilio found a large number of skeletons in a cave near the head waters of the Itapémerim. A similar excavation is reported to exist near Macahé, and yet another containing mummied bodies and urns in the Serra dos Dois Irmãos, near the head waters of the Rio Parahyba do Norte. My friend, Sr. D. S. Ferreira Penna, discovered another in Brazilian Guyana, in which was found the portrait urn I described and figured some time ago in the AMERICAN NATURALIST. Every one will remember the cave of the Atures on the Orinoco visited by Humboldt.

The burial of the dead in the hammock has been described over and over again by writers on the Brazilian Indians, and the same custom is still in force to-day among many tribes, but I do not remember having met with a description of the mode of wrapping the body in strips of bast and in palm straw.

Urn burial was practised by many ancient Brazilian tribes, and is still in use to-day in many parts of the country.

Two Tupí names are applied to the burial urn in Brazil, *ygaçába* and *camutí* or *camutím*. The former simply means a vessel to hold water, the latter a pot of any kind. It is a great mistake to suppose that either name belongs exclusively to the burial vase.

Ordinarily the vessel is not made on purpose for the body, but one of the larger earthen pots for water, or for brewing *cauim* is

used. It is safe to say that when the corpse is to be buried immediately the vase is not made on purpose. It takes time to make and ornament an earthen vessel, and true burial vases in Brazil will usually be found to contain only the cleaned bones of the dead. Those of Marajó are often made with the greatest care and most elaborately ornamented. I have already called attention to the facts that they are often true *gesichtsurnem*, wonderfully resembling those of the old world, about which so much has of late years been written by German archæologists.

As to the antiquity of the interments in the Gruta das Mumias, nothing whatever can be at present determined. At first sight, the state of preservation in some cases of hair of the skin of cartilages and dried muscles, of hammocks and bags, etc., would appear to indicate that the bodies were buried at an extremely recent date, but it is well known that, for very many years, no savage Indians have existed in the vicinity.

In the decomposition of a human body in a dry place, the soft parts disappear quickly, but the skin, the cartilages and other parts, may dry up and be preserved indefinitely. This loose material in which the bodies were buried was extremely dry, so dry that, though our explorations were made in the wet season and even during heavy rains, the negroes in working raised a thick cloud of dust, that at one time drove us from the cave. This dry material, probably containing much saltpetre, is particularly adapted for the preservation of organic substances. The human remains of the cave may be many hundreds of years old.

In the present state of our knowledge of Brazilian archæology, it is impossible to determine the tribe to which the cemetery belonged. We are ignorant of the epoch of the interment and of the history of the different tribes, that in turn have occupied the locality. Indeed, the little information that we possess of the aborigines last known to have existed in this part of southern Minas is meagre in the extreme.

THE MODE OF GROWTH OF THE RADIATES.

BY A. S. PACKARD, JR.

III. THE ACTINOZOA.

The sea anemones and coral polypes are more highly developed than the Hydroids, since the mouth opens into a double digestive cavity, which is supported for its whole length by the six primary curtains or septa. The second and lower half of the cavity enlarges greatly, and communicates with the general cavity of the body, the upper portion being entire, tubular, and forming a sort of throat opening into the proper digestive cavity. In the Hydroids, the digestive cavity, it may be remembered, is simply hollowed out of the body cavity and is a more primitive affair than that of the Actiniæ.

While in the Hydroids also the ovaries hang outside the body cavity, in the true polypes they are attached to the septa or walls of the radiating chambers, so that the eggs, when ripe, drop down into the body cavity, whence they pass out through the mouth, or, as observed by Lacaze-Duthiers, in the coral polypes through the tentacles. The chambers between the septa correspond to the water canals, or chymiferous tubes of the Hydroids.

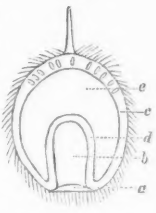
In the coral polypes the coral is secreted in the chambers, so that there are soft partitions alternating with the limestone ones. The tentacles which surround the mouth vary greatly in number. They are hollow, each communicating with a chamber.

The polypes are divided into (1), the Actinoids (Zoantharia) which either secrete no limestone, as in the sea anemones, or form a coral stock, as in the coral polypes, and have an indefinite number of tentacles, and (2), the Halcyonoids, in which the tentacles are eight in number. Such are the sea fans (Gorgonia) and Halcyonium, which does not secrete a coral stock.

Development. The life history of a polype is soon told. Naturalists are indebted to the magnificent memoirs of Lacaze-Duthiers for a full biography of not only several genera of sea anemones (*Actinia mesembryanthemum*, Bunodes and Sagartia) but also of the Gorgonia, Halcyonium, red coral, and the Astræoides, a Mediterranean form allied to Astræa.

The young sea anemone develops without any metamorphosis, directly into the adult condition. Lacaze-Duthiers could not determine by actual sight how fecundation of the egg takes place, or whether the egg passes through a morula stage or not, though he infers, with every reason, that this stage, *i. e.*, the segmentation of the egg contents, takes place in the ovary. The ovaries and spermaries are in the Actiniæ situated in the same individual; the eggs are oval, while the spermatic cells are of the usual tailed form. The fecundated egg in the state in which it was first seen by Lacaze-Duthiers was oval, and surrounded by a dense coat of transparent conical spinules. He was soon able to detect the presence of the two primitive germinal layers, the ectoderm and endoderm. Fig. 75 (from Metschnikoff) illustrates the relation of the embryonal layers in the larva of another polype which he calls "kaliphobenartige Polypen larve;" *a*, primitive opening into the gastro-vascular cavity; *b*, *c*, ectoderm; *d*, entoderm; *e*, body cavity), showing that the walls of the digestive cavity are formed by the entoderm; and Metschnikoff's figure shows that the embryo polype has a greater resemblance to the embryo starfish of the same age than the acalephs.

Fig. 75.



Ciliated larva of a Polype.

Two lobes next appear within the body, these subdivide into four, eight and finally twelve primitive lobes. This stage is represented by the corresponding stage of the coral (Fig. 77, B). Not until after the twelve primitive lobes are fully formed do the tentacles begin to make their appearance. When the first twelve tentacles have grown out, twenty-four more arise, and so on, until with its increasing size the actinia is provided with the full number peculiar to each species. The preceding remarks apply to *Actinia mesembryanthemum*, but Lacaze-Duthiers observed the same changes in two species of Sagartia and in *Bunodes gemmacea*.

Turning now to the stony corals we will give more fully the sequence of events in the life of a coral builder of the Mediterranean, the *Astræoïdes calycularis*, so faithfully narrated by Lacaze-Duthiers. Fig. 76 taken from Tenney's "Manual of Zoology" illustrates this coral in various stages of expansion.

He studied this coral on the coast of Algiers, and found that reproduction took place between the end of May and July, the

young developing most actively at the end of June. Unlike Actinia, which is always hermaphrodite, this coral is rarely so, but the polypes of different branches belong to different sexes.

As in the other polypes, including Actinia, the eggs and spermatic particles rupture the walls of their respective glands situated in the fleshy partitions. As in Actinia, Lacaze-Duthiers thinks the fecundation of the egg occurs before it leaves the ovary, when also the segmentation of the yolk must take place. Unlike the embryo Actinia, the ciliated young of the coral, after remaining in the digestive cavity for three or four weeks, make their way out into the world through the tentacles. "Many times," says Lacaze-Duthiers "have I seen the end of the tentacle break and let out

Fig. 76.

Coral polype (Astræoides calycularis) expanded.

the embryo." The appearance of the embryo, when first observed, was like that in Fig. 77, A, an oval, ciliated body with a small mouth and a digestive cavity. This may be called the gastrula, adopting Hæckel's phraseology.

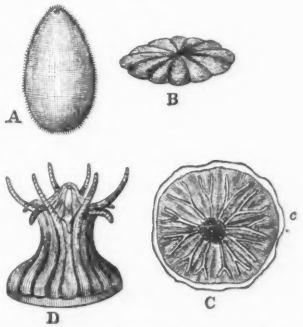
The gastrula changes into an actinoid polype in from thirty to forty days in confinement, after exclusion from the parent, but in nature in a less time, and it probably does not usually leave the mother until ready to fix itself to the bottom.

Before the embryo becomes fixed and the tentacles arise, the lime destined to form the partitions begins to be deposited in the endoderm. Fig. 77, C, shows the twelve rudimentary septa. These after the young actinia, or "actinula" (Allman), has become stationary, finally enlarge and become joined to the external

walls of the coral now in course of formation (Fig. 77 C, *c*) forming a groundwork or pedestal on which the actinula rests. D represents the young polype resting on the limestone pedestal.

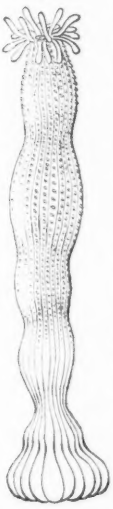
In the experience of Lacaze-Duthiers it happened that the embryo polype which had been swimming about in his jars for about a month, suddenly, within the space of three or four hours after a hot sirocco had been blowing for three days, assumed the form of small disks (Fig. 77, B), divided as in the Actinia into twelve small folds forming the bases of the partitions within.

Fig. 77.



Development of a coral polype, Astræoides calycularis. After L. Duthiers.

Fig. 78.



Halcampa albida.

The tentacles next arise, being the elongation of the chambers between the partitions, six larger and elevated, six smaller and depressed (Fig. 77, D). The definitive form of the coral polype is now assumed, and in the Astræoides it becomes a compound polypary.

The singular floating young Edwardsia, originally described under the name *Arachnactis*, has been found by Mr. A. Agassiz to be the early swimming stage of Edwardsia, a worm-like Actinian, which, like *Halcampa albida* (Fig. 78[1]), lives in the sand or mud, unattached to any fixed object.

Kowalevsky has lately found that the Cerianthus, a gigantic Actinia which lives in a tube in the mud at great depths, has a free swimming early stage like Edwardsia.

The following is a summary of the changes undergone by the polypes so far as known:—

1. Egg fertilized by true spermatozoa.
2? Morula.

[1] This figure was kindly loaned by Professor S. F. Baird, U. S. Commissioner of Fish and Fisheries.

3. Planula (Gastrula).
4. Actinula, with twelve primitive tentacles.
5. Adult actinia or polype.

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Lacaze-Duthiers. Développment des Coralliaires (Lacaze-Duthiers' Archives de Zoologie Experimentale, etc. 1872, 1873).

IV. THE CTENOPHORÆ.

These beautiful animals derive their name Ctenophoræ, or "comb-bearers," from the vertical rows of comb-like paddles, situated on horizontal bands of muscles, which serve as locomotive organs, the body not contracting and dilating as in the true jelly fishes. In their organization they are much more complicated than any animals of which we have yet spoken, as it has been shown by the two Agassizs that they have a true digestive cavity, passing through the body cavity, with a posterior outlet, and originating in the same manner as in the Echinoderms. From this alimentary canal are sent off chymiferous tubes which "correspond in every respect with the water tubes of the Echinoderms" (A. Agassiz). The rows of paddles are intimately connected with the chymiferous tubes, so that the movements of the body are in direct relation with the act of breathing. Moreover these animals, while in the disposition of the organs following the radiate plan of structure, are also more truly bilateral than any of the lower classes of radiates. The sexes are united in the same individual; the ovaries in Idyia are on one side of the main chymiferous tube, and the spermaries on the other, both being brilliantly colored.

Referring the reader for farther details to Mr. A. Agassiz's "Sea Side Studies," where these animals are described and illustrated with sufficient detail for the general reader, we will now turn to their mode of growth, under the guidance of the same author, whose recent richly illustrated memoir, with others by Kowalevsky and Fol leaves but few gaps to be filled by future observers.

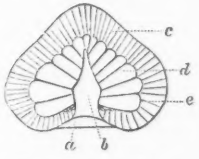
Development. Agassiz states that the Ctenophoræ are readily kept in confinement, and from twelve to twenty-four hours after they are captured lay their eggs, either singly or in strings, or, as in Idyia, in a thick slimy mass. The Ctenophoræ of our eastern coast spawn from late in July through August and September. "The young brood developed during the fall, comes to

the surface again the following spring as nearly full-grown Ctenophoræ, to lay their eggs late in the summer." Fortunately the eggs are so transparent that in some forms (Pleurobrachia and Bolina) the embryology can be studied, not only in the egg but also through nearly all the earlier stages of the larva.

Selecting Pleurobrachia as an example of the mode of growth, we find that as in Idyia the egg consists of two layers, *i. e.* an inner yolk mass and an outer, thin, finely granular layer surrounded by a transparent envelope. The inner mass acts merely as a nutritive mass, while the outer is the true embryonic layer, which builds up the body at the expense of the central nutritive mass. No nucleus nor nucleolus has been observed by Agassiz in the eggs of any Ctenophoræ, after they are once laid, until late in the stage of segmentation. The egg divides into four and again eight spheres of segmentation, each of which has, like the egg, originally an outer and inner mass. In a second stage of segmentation small cells arise which surround the original eight large cells. From these small cells the external organs are destined to arise, while the larger cells form a yolk mass out of which the internal organs arise.

The embryonal layer is next formed, then the outer wall by "the gradual encroachment of the actinal cells over the whole of the yolk mass." Finally, the mouth (actinostome) of the germ is formed, and afterwards the digestive cavity, which results from an invagination of the outer embryonic layer (ectoderm). Fig. 79 (after Metschnikoff) represents the larva of a Cydippe; *a*, primitive opening; *b*, gastro vascular cavity; *c*, ectoderm; *d*, endoderm; *e*, interspace corresponding to the body cavity of the larva of the polype. The development of the chymiferous tubes is succeeded by that of the locomotive flappers, eight or nine pairs in each row appearing before the young leave the egg, and of the fringed tentacle, which attains a great length after the young is hatched.

Fig. 79.

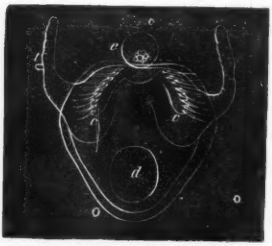


Gastrula of Cydippe.

Finally the definitive form of the Pleurobrachia is attained before it leaves the egg, as seen in Fig. 80 (*t*, tentacles; *e*, eyespeck; *c*, *c*, rows of locomotive flappers; *d*, digestive cavity; greatly magnified after A. Agassiz).

Fig. 81 shows the young Pleurobrachia swimming about in the egg just before hatching, and in Fig. 82 (after A. Agassiz), we see the young after hatching (magnified) with nearly the same form as the adult; *f* indicates the funnel leading to the anal opening, *l*, the lateral tubes, and *c c c' c'* the rows of locomotive flappers. The remaining changes are slight, and there is not even a slight metamorphosis, the body simply becoming spherical and the tentacles increasing enormously in length. In Bolina and its allies, as A. Agassiz states, "the morphological changes are very great, and it would indeed puzzle the most accurate systematist to recognize in the early stages of some of the Mnemidæ the young of well known genera. We cannot say that there is a metamorphosis in the ordinary sense of the word, as supposed by Gegenbaur, but there certainly are remarkable changes, such as the almost total suppression of the tentacular apparatus, the development of auricles, of lobes, with their complicated winding chymiferous tubes, which alter radically the appearance of the Ctenophoræ at successive periods of growth, and present between the younger and the older stages differences usually considered as of great systematic value."

Fig. 80.

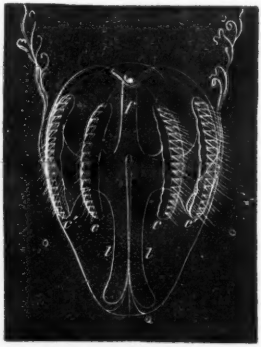


Young Pleurobrachia still in the Egg.

Fig. 81.

Young Pleurobrachia swimming in egg ready to hatch.

Fig. 82.



The same after hatching.

The summary of stages is very brief, the Ctenophore passing through three phases:—

1. Egg stage.
2. Morula state.
3. Adult form, assumed before hatching.

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Fol. Ein Beitrag zur Anatomie und Entwickelung einiger Rippenquallen. (Siebold and Kölliker's Zeitschrift, 1869.)
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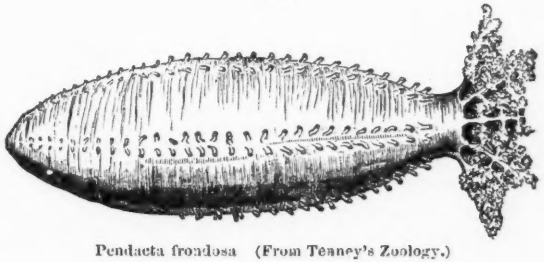
V. THE ECHINODERMS.

The Echinoderms (starfishes, sea urchins and sea cucumbers) are far more complicated than the Cœlenterates, having a true alimentary canal passing through the general cavity of the body. In them for the first time among the Radiates appears a well developed nervous system. Not only do the young exhibit a bilateral symmetry, but in the higher forms, as the spantangoid sea urchins,

Fig. 83.



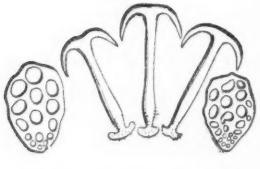
Pendacta frondosa (From Tenney's Zoology.)

this is quite well marked; and there is a dorsal and ventral side. Still, in the generality of the forms, the radiated plan of structure is remarkably adhered to, the body as distinctly made up of sphæromeres, or wedge-shaped sections of the body, as the worms are of segments (arthromeres). In this and other respects, as well as the form of the larvæ, there is a remarkable parallelism between the worms and echinoderms.

We will briefly review some of the anatomical features of the Echinoderms, in order to understand their complicated mode of growth.

The stomach and intestinal canal either pass straight or in a spiral course through the body, as in the sea urchins (Fig 103) and Holothurians (Fig. 83), and open out at the opposite end; or, as in the Antedon (Comatula), the anal opening is situated near the mouth, while in the Ophiurans (Fig. 85) and Luidia and Astropecten, low starfishes, the undigested food is rejected from the mouth. In the starfishes and Holothurians, the alimentary canal opens into five voluminous cæcal appendages. These are wanting in the Ophiurans, and there are but two in Astropecten. They are in connection with the complicated water tubes, which consist of a canal surrounding the mouth and sending branches out into the rays of the starfishes in communication with the locomotive organs or suckers, called ambulacra. The water fills the tubes through a duct leading from the sieve-like plate, situated in the dorsal (abactinal) portion of the body. Near this duct is the pulsating tube, the so-called heart.

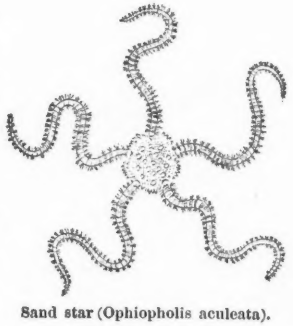
Fig. 84.



Hooks and Plates of Synapta.

The Echinoderms are further distinguished by the body walls secreting calcareous plates, often forming a solid limestone shell, as in the sea urchins; or the plates are smaller and movable as in the starfishes, or as in the sea cucumbers they are microscopic, buried in the skin; sometimes, as in the Synapta forming anchor-like hooks and small plates (Fig. 84).

Fig. 85.



Sand star (Ophiopholis aculeata).

The sexes are as a rule distinct. In *Ophiura squamata* and Synapta they are united in the same individual. The ovaries and testes are gland-like masses situated at the base of the arms in the starfishes, or between the ambulacra in the sea urchins. The ovaries are red or yellow, the male glands

whitish. In the Ophiurans the eggs and spermatozoa pass out of the body through little holes between the plates on the under side of the body. In those starfishes in which the alimentary canal is a blind sac, the eggs are emptied into the body cavity; but how they pass out is unknown. In some starfishes they escape through certain (interradial) plates on the back. In the Echinoids they make their exit from between the ambulacra. In the Holothurians, however, there is a duct leading from the generative gland opening out near the mouth, between the tentacles. The eggs are usually round, and minute; the spermatozoa of the usual tailed form. Fertilization takes place in the water.

Remembering that there are five well-marked divisions of Echinoderms, *i.e.*, *Crinoidea*, *Ophiuroidea*, *Asteroidea*, *Echinoidea*, and *Holothuroidea*, we will now review some of the main points in the mode of development of the respective orders.

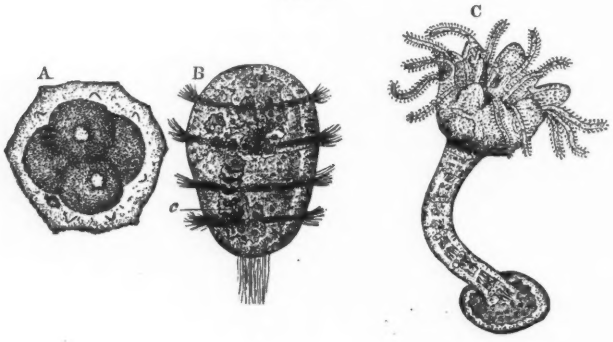
Development of the Crinoids. While we know nothing of the mode of development of the true Pentacrinus and Rhizocrinus, the lineal descendants of the Crinoids of the earlier geological ages, we have quite full information regarding the life-history of the Antedon, which is for a part of its life stalked, and is in fact a true crinoid.

The following account is taken (sometimes word for word) from Professor Wyville Thompson's researches on the *Antedon rosaceus* of the British coast. The ovaries open externally on the pinnules of the arms, while there is no special opening for the spermatic particles, and Prof. Thompson thinks they are "discharged by the thinning away and dehiscence of the integument." The ripe eggs hang for three or four days from the opening like a bunch of grapes, and it is during this period that they are impregnated. The egg then undergoes total segmentation. Fig. 86, A, represents the egg with four nucleated cells, an early phase of the mulberry or morula stage. After the segmentation of the yolk is finished, the cells become fused together into a mass of indifferent protoplasm, with no trace of organization, but with a few fat cells in the centre. This protoplasmic layer becomes converted into an oval embryo, whose surface is uniformly ciliated. The mouth is formed, with the large cilia around it, before the embryo leaves the egg. When hatched, the larva is long, oval, and girded with four zones of cilia, with a tuft of cilia at the end, a mouth and anal opening, and is about ·8 millimetre in length. The body cavity is formed by an

inversion of the primitive sarcode layer which seems to correspond to the ectoderm.

Within a few hours or sometimes days, there are indications of the calcareous areolated plates forming the cup of the future crinoid. Soon others appear forming a sort of trellis work of plates and gradually build up the stalk, and lastly appears the cribriform basal plate. Fig. 86, B, *c*, represents the young crinoid in the middle of the larva, whose body is somewhat compressed under the covering glass. Next appears a hollow sheath of parallel calcareous rods, bound, as it were, in the centre by the calcareous plates. This stalk (B, *c*) arises on one side of the digestive

Fig. 86.



Development of a Crinoid (Antedon).

cavity of the larva, and there is no connection between the body cavity of the larva and that of the embryo crinoid.

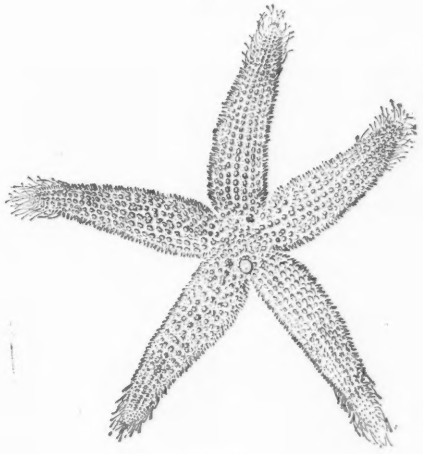
Two or three days after the appearance of the plates of the crinoid, the larva begins to change its form. The mouth and digestive cavity disappear, not being converted into those of the crinoid. The larva sinks to the bottom resting on a seaweed or stone to which it finally adheres. The Pentacrinus is embedded in the former larval body (the cilia having disappeared), now constituting a layer of sarcode conforming to the outline of the Antedon.

Meanwhile the cup of the crinoid has been forming. It then assumes the shape of an open bell; the mouth is formed, and five lobes arise from the edges of the calyx. Afterwards five or more, usually fifteen tentacles, grow out, and the young Antedon appears

as in Fig. 86, C (after Thompson). The walls of the stomach then separate from the body-wall. The animal now represents the primary stage of the crinoids, that which is the permanent stage in the Pentacrinus and its fossil allies. The Antedon, however, in after life separates from the stalk and moves about freely.

Development of the Starfish. We will select as a type of the mode of development of the starfishes, that of the common five finger, Asterias (Fig. 87), as worked out with great thoroughness

Fig. 87.

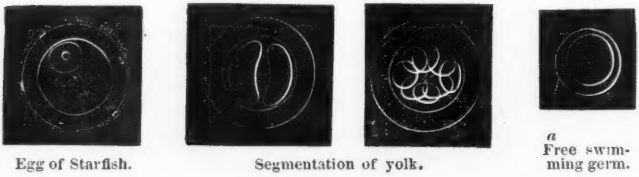


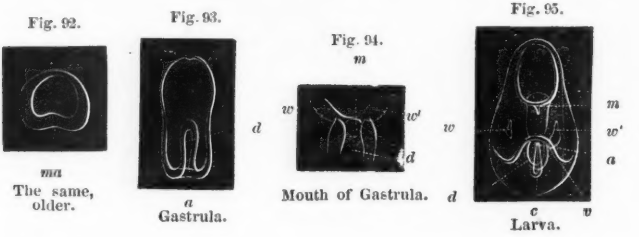
Asterias.

by Mr. A. Agassiz, and given in the "Seaside Studies." The accompanying illustrations are taken from this work and the original memoir, through the kindness of the author, whose description is here freely used.

Fig. 88 shows the transparent spherical egg, enclosing the germinative vesicle and dot, and Figs. 89, 90, illustrate the segmentation of the yolk into two and eight and more cells, enclosing a central cavity. After this the embryo hatches and swims about as a transparent sphere (Fig. 91). A depression (Fig. 92, *ma*) then begins to appear, the body elongates, and this depression forms an inversion of the outer wall of the body (ectoderm), constituting the body cavity (*d*, Fig. 93, *a*), being the provisional mouth-

opening, afterwards becoming the anal opening; at this time, however, serving both for taking in and rejecting the food). From the upper extremity of the digestive cavity next project two lobes (*w*, *w'*, Fig. 94, *m*, mouth). These separate from their attachment and form two distinct hollow cavities (*w*, *w'*, Fig. 95, *a*, *d*, *c*, digestive system; *v*, vibratile chord; *m*, mouth). Here begins the true history of the young starfish, for these two cavities will develop into two water-tubes, on one of which the back of the starfish, that is, its upper surface, covered with spines, will be developed, while on the other, the lower surface, with the suckers and





tentacles, will arise. At a very early stage one of these water tubes (*w'* Fig. 96) connects with a smaller tube opening outwards, which is hereafter to be the madreporic body (*b*, Fig. 96). Almost until the end of its growth, these two surfaces, as we shall see, remain separate and form an open angle with one another; it is only toward the end of their development that they unite, enclosing between them the internal organs, which have been built up in the meanwhile.

"At about the same time with the development of these two pouches, so important in the animal's future history, the digestive cavity becomes slightly curved, bending its upper end sideways

till it meets the outer wall, and forms a junction with it (*m*, Fig. 97; *o*, digestive cavity). At this point, where the juncture takes place, an aperture is presently formed, which is the true mouth. The digestive sac, which has thus far served as the only internal cavity, now contracts at certain distances, and forms three distinct, though connected cavities as in Fig. 96, viz., the œsophagus leading directly from the mouth (*m*) to the second cavity or stomach (*d*), which opens in its turn into the third cavity, the alimentary canal. Meanwhile the water-tubes have been elongating till they now surround the digestive cavity, extending on the other side of it beyond the mouth, where they unite, thus forming a

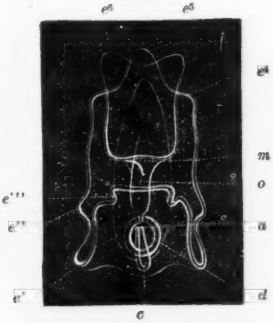
Fig. 96.

Profile view of Larva.

Fig. 97.

Larva.

Fig. 98.



Larva with arms developing.

Y-shaped tube, narrowing at one extremity, and dividing into two branches toward the other end, Fig. 98.[2]

"On the surface where the mouth is formed, and very near it on either side, two small ones arise, as *v* in Fig. 95; these are cords consisting entirely of vibratile cilia. They are the locomotive organs of the young embryo, and they gradually extend until they respectively enclose nearly the whole of the upper and lower half of the body, forming two large shields or plastrons (Figs. 98, 99). The corners of these shields project, slightly at first (Fig. 98), but elongating more and more until a number of arms are formed, stretching in various directions (Figs. 99, 100)[3] and, by their con-

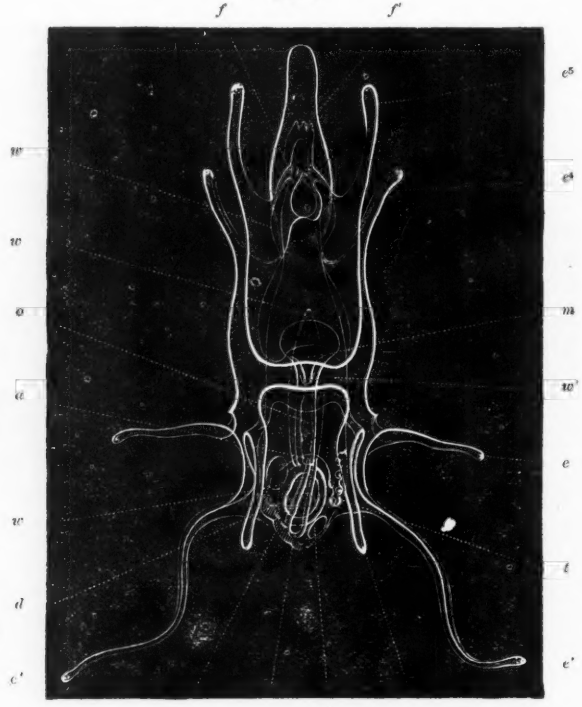
[2] Fig. 98 *a*, anus; *c*, intestine; *e' e'' e''' e⁴ e⁵ e⁶*, arms; *o*, œsophagus.

[3] Figs. 99, 100, side view of 99. Adult larva, so-called Brachiolaria, lettering the same in all the figures; *t*, tentacles of young starfish; *f f*, brachiolar appendages; *r*, back of young starfish. Fig. 101, *t'*, odd tentacle.

stant upward and downward play, moving the embryo about in the water" (A. Agassiz).

Having reached the Brachiolaria stage, the body of the future starfish begins to develop. On one of the water-tubes (w') the tentacles of the future starfish arise as a series of lobes (t); while

Fig. 99.



Full grown larva of Starfish, or Brachiolaria.

on the opposite water-tube (w), arise a number of little calcareous rods, which afterwards form a continuous net-work; r indicates the back of the young starfish. The larva now shrinks and drops to the bottom and attaches itself there by means of the short arms (ff' Fig. 99). The starfish now absorbs the larva, and

appears of an oval form with a crenulated edge, and soon reaches a stage indicated by Fig. 101. (Fig. 102, the same seen in profile).

In this stage it remains probably two or three years before the arms lengthen and the adult form is assumed.

Fig. 100.

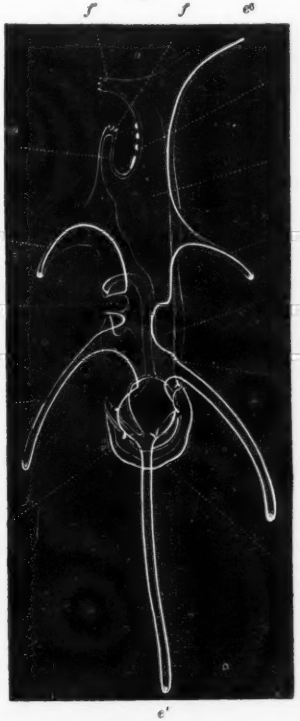


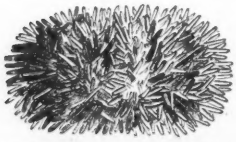
Fig. 99 seen in profile.

The development of the Ophiurans is much like that of the starfish, with some characters of the embryo sea urchin. The larva of the sand star (Ophiura) is called a Pluteus, and is remarkable for the great length of two of the arms.

Development of the Echinoids. The researches of Mr. A. Agassiz, who has given us a very complete history of the common sea urchin of the northern shores of the United States in his "Revision of the Echini," will be our guide in these studies. The earlier stages of development were obtained by artificial fecundation of the egg during February. The early embryonic stages are much as described in the starfishes, the process requiring but a few hours. The embryo when hatched is like that of the starfish at the same period (Fig. 91) and then it passes into the gastrula stage (Fig. 104, lettering the same in all the figures as in those of the starfish) the digestive cavity being formed by an inversion of the ectoderm. "The embryo, in escaping from the egg, resembles a starfish embryo, and it would greatly puzzle any one to perceive any difference between them. The formation of the stomach, of the œsophagus, of the intestine, and of the water tubes takes

place in exactly the same manner as in the starfish, the time only at which these different organs are differentiated not being the same. In figure 105 we see the beginning at w and w' of the water tubes arising as pouches sent off from the digestive cavity, and T-shaped rudiments of the limestone rods (r), so characteristic of the larva of the sea urchin are now visible."

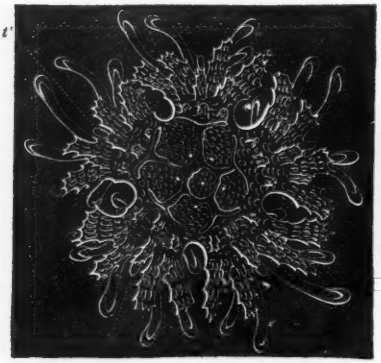
Fig. 103.



Common Sea Urchin (Echinus).

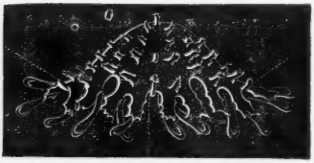
Fig. 106 represents the larva well advanced towards the pluteus stage. It is now in the tenth day after fecundation.[4] The arms are now well marked, and the "vibratile epaulettes" appear. When the larva is twenty-three days

Fig. 101.



Young Starfish seen from the back.

Fig. 102.



Young Starfish seen in profile.

old, the rudiments of the five tentacles of the sea urchin appear, the first one on the left water tube. The arms have increased in length, until in the full-grown larva, now called the pluteus (Figs. 107, 108, the same seen sidewise) the arms with the calcareous rods supporting them are of great length, opening and shutting like the rods of an umbrella; while the sea urchin growing within has concealed the shape of the digestive cavity of the larva, and the spines are so large as to conceal the tentacles.

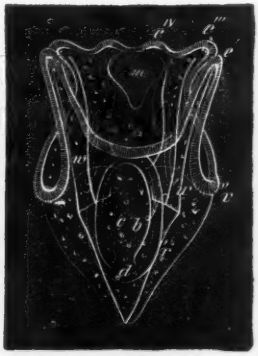
[4] Fig. 106, e–e^{iv} arms; v-v', vibratile chord, w w^4, earlets, water tubes; a o d c, digestive system; r–r''' solid rods of the arms; m, mouth; b, madreporic opening. Fig. 107, f, brachilar appendages.

The pluteus, a nomadic stage of the echinus, is as Mr. A. Agassiz states "a scaffolding in which the future sea urchin plays but a secondary part, and is composed of two open spirals, the one to form eventually the complicated abactinal system (the interambulacral and ambulacral plates), the other to form the water system, and holding between them the digestive cavity and other organs of the pluteus, which as yet appear to have no connection whatever with the spines of the future Echinus. Yet towards the end of the nomadic pluteus life a few hours are sufficient to resorb the whole of the complicated scaffolding, which has been the most striking feature of the Echinoderm, and it passes into

Fig. 104.

Fig. 105.

Fig. 106.



Development of the Pluteus of the Sea Urchin.

something which, it is true, we could hardly recognize as an Echinus, yet has apparently nothing in common with its former condition."

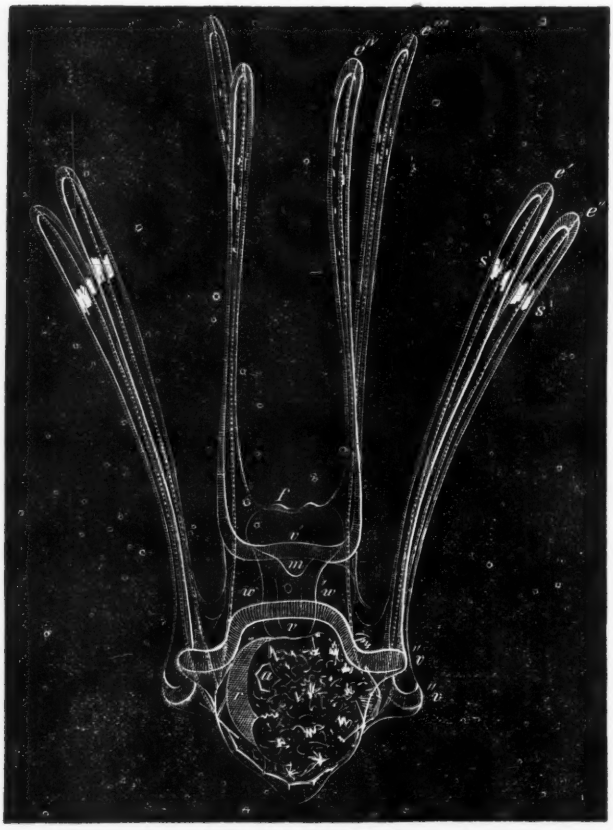
From this time the body of the pluteus is absorbed by the growing sea-urchin; the spines and suckers of the latter increasing in size and number with age, and by the time the larval body has disappeared the young Echinus is more like the adult than the starfish at the same period in life. Fig. 109 (*tt*, tentacles; $s''s'''$, spines) represents the sea urchin very soon after the resorption of the pluteus.

In after life the young sea urchin with its few and large spines resembles Cidaris and a number of allied forms, showing that

these genera, which appeared earlier geologically than our common Echinus (Fig. 103, *Strongylocentrotus Dröbachiensis*), are lower in development.

Development of the Holothuroids. Of the development of our

Fig. 107.



Pluteus of the Sea Urchin.

native sea cucumbers our knowledge is exceedingly fragmentary, and for nearly all that we do know of the mode of growth of these animals in general, we are indebted to the elabo-

rate researches of the distinguished J. Müller. He figures the earliest stage of the larval Holothurian, which he calls an "Auricularia." The course of development is much as in the starfishes. The earliest stage known resembles that of the starfish represented by Fig. 93. It then passes through a stage represented by Fig. 96, when the mouth and digestive tract is formed, and again a stage analogous with Fig. 98. The Auricularia when fully grown, is cylindrical, annulated, with four or five bands of cilia, usually with ear-like projections, whence its name Auricularia. Before it becomes fully formed the young Holothurian begins to grow near the side of the larval stomach, the calcareous crosses appear and the tentacles of the future Holothurian bud out. The ear-like projections disappear, the Auricularia becomes cylindrical, and is now called the "pupa." The Auricularia is gradually absorbed and the young Holothurian strikingly resembles a worm. In this pupa stage, in certain transparent forms observed by Müller, the intestine of the embryo Holothurian could be observed twisted on itself, with the mouth surrounded by tentacles. The only observations published on our native Holothurians are those of Mr. A. Agassiz, on Cuvieria, our large red, heavily plated sea-cucumber, which inhabits stony bottoms in deep water. The young are of a brilliant vermilion. In the earliest stage observed by Mr. Agassiz (Fig. 110 *l*, "pupa;" *g*, tentacles);

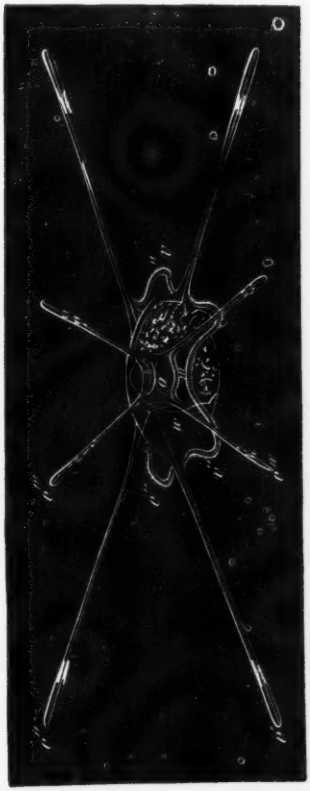
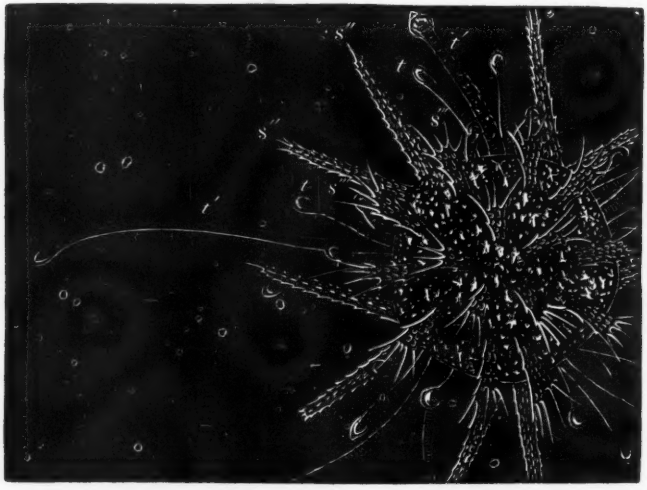


Fig 108. Profile view of 107.

the "pupa" or second form of the Auricularia is very large and the tentacles do not project beyond the body, as they afterwards do (Fig. 111) when the Auricularia is nearly absorbed by the growing Holothurian. In a succeeding stage the tentacles begin to branch, where before they were simple and knobbed. At this time the œsophagus, stomach, intestine and anus are developed, and there is a ring of limestone rods and crosses around the mouth. The madreporic body (*b*) has not yet been drawn within the body.

Fig. 109.



The young Echinus.

Finally, the Auricularia becomes wholly absorbed, the tentacles are much branched and capable of retraction within the body; the tegument secretes limestone plates, the suckers are developed in the ambulacral rows and the adult form is attained without important changes. Fig. 83 represents a common sea-cucumber of our coast.

Some holothurians, as well as starfishes and ophiurans, as observed by Mr. A. Agassiz, undergo their larval (*i. e.*, Pluteus, Brachiolaria and Auricularia) phases of development above described without leaving the parent, in pouches held over the mouth of the parent, making their escape in a form approaching that of the adult.

Metschnikoff has made some valuable comparisons between the ciliated embryos of the Cœlenterates and Echinoderms, and shows that the primitive body-cavity of the former is not homologous with the peritoneal cavity (*i. e.*, the space in which the digestive canal hangs) of the Echinoderms. He also shows that while the primitive body cavity of the Cœlenterates remains permanently as the digestive tract; in the Echinoderms it is temporary and embryonic. Metschnikoff, on embryological grounds (a view which the structure of the adult animals confirms), thinks that there is the same similarity between the Cœlenterates (Acalephs and Ctenophoræ) and Echinoderms, as between the higher worms (Hirudineæ, Gephyrea and Annelides), and the Crustacea and Insects.

Fig. 112.

Larva of Cuvieria.

Reproduction by fission as in the Actiniæ and jelly fishes very rarely occurs in the Echinoderms. An Ophiuran deprived of all

Fig. 110.

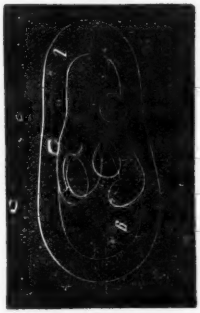
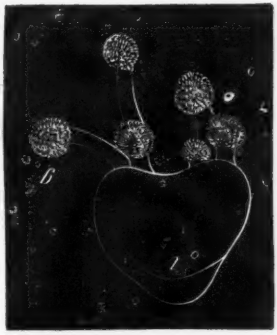


Fig. 111.



Development of a Holothurian (Cuvieria).

its arms will reproduce them by budding, and Lütken shows that certain starfishes divide in two spontaneously, having three arms

on one side and three on the other, while the disk looks as if it had been cut in two by a knife, and three new arms had then grown out from the cut side.

Echinoderms as a rule, then, are reproduced alone by eggs and sperm cells. After fertilization of the egg they pass through:

1. Morula stage.
2. Gastrula stage.
3. A larval, temporary stage (Pluteus, Brachiolaria, Auricularia).
4. The Echinoderm grows from a water tube of the larva, finally absorbing the latter, whose form is often materially changed during the process. It thus undergoes a true metamorphosis, in a degree comparable with that of some insects.

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REVIEWS AND BOOK NOTICES.

THE GEOLOGICAL SURVEY OF MISSOURI. — We have too long delayed our notice of the two octavo volumes from the geological survey of Missouri, which, though bearing the date of 1873, were not distributed till 1874. The first of these is a collection of reports from 1855 to 1871, by Messrs. Brodhead, Meek & Shumard, and the second, the results of the work of 1872, is devoted to the iron and coal deposits of the state. Of these the former are described by Dr. Adolph Schmidt, and the latter by Mr. Brodhead; in addition to which the late director, Prof. Raphael Pumpelly, has prefixed an important chapter on the geology of the Pilot Knob district, and its iron ores, from which, and from the copious descriptions of Dr. Schmidt, we gather a pretty complete account of this extremely curious region. Rising above the floor of horizontal palæozoic deposits, the 3d Magnesian limestone of Swallow, a member of a group of strata supposed to correspond to the Potsdam of New York, appear numerous hills of crystalline rock, described as exposed portions of the skeleton of the eastern part of

the Ozark Mountains; which formed an archipelago in the palæozoic sea, and are now from 300 to 700 feet above the limestone at their base. The Pilot Knob group includes four of these, and the Iron Mountain is another and distinct mass. All of these consist wholly or in part of quartziferous porphyry or orthophyre, but in the vicinity of these porphyry hills are others composed of granites, often chloritic or hornblendic, some of them capped by the porphyry which is considered as a newer rock, and, it is suggested by Pumpelly may be the youngest member of the Eozoic (Archæan) rocks of the region. He, however, adds in a note that the red granites may be an exception to this supposed rule. These porphyries present some considerable variations in character, but may be described as having a fine grained compact base or matrix with conchoidal fracture, composed of an intimate mixture of feldspar and quartz, in which are generally disseminated small crystalline grains of vitreous quartz, and crystals of pink or white feldspar, generally triclinic. The colors of this rock are various shades of yellow, red, gray, brown and black, and it is often banded in its structure, sometimes exhibiting thin layers, occasionally with alternations of quartz, in addition to which, according to Pumpelly, it is stratified on an immense scale. Epidote, chlorite and a steatitic mineral occasionally occur in it, and magnetic and specular iron ores are often disseminated through the mass. To those familiar with the geology of our eastern coast it is only necessary to say that these porphyries seem to be identical with those of Lynn, Saugus, Marblehead and Newburyport, Massachusetts, which are traced thence along the coast of Maine and New Brunswick, and are well developed about Passamaquoddy Bay, where they occasionally contain small deposits of iron ore. These porphyries have already been compared by Hunt with those of Missouri and with similar ones on the north shore of Lake Superior. As seen on the coast of New Brunswick, they are, according to him, intimately associated and interstratified with schistose rocks, supposed to be of Huronian age.[1]

At Pilot Knob, the excavations in the ore-deposit have exposed a considerable section of the strata, which dip at a moderate angle to the southwest, and consist at the base of several varieties of banded porphyry, one of these containing iron ore in grains and

[1] T. Sterry Hunt, Chemical and Geological Essays, p. 187

in streaks. Above these lies a thin layer of clay slate, followed by a great mass of bedded iron ore (about forty feet) divided into two parts by a layer of a few feet of clay slate, talcose in parts. The upper portion, which is thin-bedded and flag-like, is less pure than the lower, containing a considerable admixture of silicious matter, and is overlaid by about 100 feet of well-bedded conglomerate rock, consisting of pebbles or more or less angular fragments of porphyry and gray quartz, in a matrix of granular iron ore, occasionally with grains of quartz and a soft clayey matter. In the lower part of this the conglomerate character is less obvious, and it appears to be a uniform ore-bearing porphyry with thin layers of fine conglomerate. The iron oxyd is essentially hematite or peroxyd, but the rock possesses a decided magnetic polarity. While the great deposit of ore is here newer than the porphyry, and seems to be the cement of a conglomerate made up of the ruins of this rock, it is found in the Iron Mountain in this region, in veins intersecting a clayey material, which is nothing but the porphyry decomposed *in situ*. In a deeper cutting, however, the hard unaltered porphyry has been met with. Prof. Pumpelly calls attention to several curious phenomena dependent upon the decay of the crystalline rocks in this region. In some cases partial decomposition of the granites has left at their outcrop great polygonal rounded blocks, often hundreds of tons in weight. Elsewhere, the chloritic granites for fifty feet, and probably for many times that depth, are completely disintegrated and decomposed. In the case of the decayed porphyry of the Iron Mountain, the effect of the atmospheric waters upon this mass, "part iron and part clay," has been to remove the latter, so that when the mountain was first examined, it exhibited a layer of from four to twenty feet or more in thickness, of rounded masses and grains of pure compact red hematite or specular ore, with very little clay. This residual detritus, as remarked by Pumpelly, represents a great amount of porphyry decomposed and removed since the ore-veins bear but a small proportion to the whole mass of the rock. In the sediments around the base of the mountain are large stratified accumulations of similar detrital ore, which were washed down the slope and "concentrated by the waves of the Silurian ocean," thus showing the great antiquity of this process of decay.

The ore at Cedar Hill near Pilot Knob is compact, holding grains of limpid quartz, and has, according to Pumpelly, the as-

pect of a porphyry, in which the whole matrix has been replaced by iron ore. This forms irregular masses in ordinary porphyry, which in other localities contains iron ores highly manganesian, and even deposits of nearly pure oxyd of manganese. Crystals of orthoclase, feldspar and grains of quartz, are found imbedded in a compact manganese ore, which, according to Pumpelly, may be supposed to have replaced the matrix, leaving the crystalline elements intact, while in other portions the replacement has been complete, manganese-oxyd taking the place of the grains of quartz, and the feldspar crystals. With these manganiferous porphyries is associated carbonate of lime, sometimes forming layers of pink and greenish crystalline limestone several inches in thickness, interlaminated with a schistose jaspery or porphyroid rock. To account for these various associations, Prof. Pumpelly suggests two hypotheses, the one that the porphyry, both matrix and included crystals, may have been replaced by oxyd of iron or of manganese, and the other that the parent rock may have been a limestone, parts of which were changed into ore by a similar replacement, "while the porphyry now surrounding the ores may be due to a previous, contemporaneous or subsequent replacement of the lime-carbonate by silica and silicates." The important fact is noted that chemical analysis shows that the remaining porphyry, intimately associated with the ore, has undergone no change, but retains its normal constitution.

The ore-deposit of Iron Mountain is, according to Dr. Schmidt, a great irregular vein of specular ore, more or less split up, and including masses of wall-rock, but accompanied by numerous smaller veins. He supposes the ore to have been deposited in fissures in the unaltered porphyry, which was further cracked and fissured by the crystallization of the ore, while this was itself subsequently broken by the contraction and the decomposition of the porphyry; in fact, the angular fragments of ore in the latter can scarcely be otherwise explained. The writer can, from his own observations, bear witness to the careful statements of facts in the case of these curious ore-deposits as given in the present volume, and affirm that the singular perplexity of the phenomena at the Iron Mountain can scarcely be better described or explained than has been done by Dr. Schmidt. As regards the origin of the ore-deposits Dr. Schmidt considers the various hypotheses of igneous injection, of sublimation and of segregation, and rejects

them in turn, in favor of that of aqueous deposition from infiltrating waters. The ores at Shepherd Mountain are similar vein-deposits, but the porphyry is here seen in an undecayed state.

As regards the very unlike deposits of Pilot Knob, Dr. Schmidt accepts the first hypothesis of Prof. Pumpelly, and supposes that solutions, similar to those which deposited the ore in the fissures of the porphyries elsewhere, have here effected the conversion of the porphyry into ore. It is, as he admits, difficult to explain in this view, the removal of the resulting silicate of alumina, and not less difficult to explain the removal or replacement of the quartz, as supposed by Pumpelly. When we consider that iron oxyds are frequent elements in gneissic and other crystalline rocks, and that they have been directly deposited in later sedimentary formations, it will seem to many simpler to accept the hypothesis that these iron and manganese oxyds in the porphyries and conglomerate beds, instead of having come from the replacement either of feldspar and quartz or of carbonate of lime, may have been deposited as we now see them.

Besides these ores associated with the Eozoic rocks, Dr. Schmidt describes several other classes of iron-ore deposits, one of the most interesting of which occurs in the sandstones immediately above the 3d Magnesian limestone above named, and often fills small basins or excavations in this sandstone, nearly vertical walls of which are seen to limit the ore-deposit. The ore in these is stratified, and is often both overlaid and underlaid by beds of clay, flint and broken sandstone, and, it is suggested, may have been deposited in cavities produced by a subsidence of the strata into caverns in the limestone beneath. The ore is sometimes specular red hematite, and at other times limonite, occasionally also magnetite, and sometimes includes rounded masses of ferruginous limestone with crystals of iron-carbonate. This association leads Dr. Schmidt to suggest as an alternative hypothesis, that these deposits may have been formed by the transmutation of limestone deposits previously occupying these basins. To this class belong the ores of the Merramec district.

In the Carboniferous series again, deposits of red hematite ore occur in sandstone, forming nodular or concretionary masses or regular beds. In one locality also, we have here described a large cavern or sink in the Receptaculite limestone at the summit of the Trenton, in which occur stratified layers of hematite and limonite,

with more or less heavy spar, the whole capped by a bed of crystalline heavy spar, including galena. The 3d Magnesian limestone is also metalliferous, and holds in drusy cavities crystals of pyrite and chalcopyrite. It sometimes contains more than the proportion of magnesian carbonate required to form dolomite, a not very common circumstance.

The coal measures of the state, belonging chiefly to the great western coal-field, and occupying an area of nearly 23,000 square miles, are described by Mr. Brodhead with much detail. The coal seams are generally thin, though some in the lower measures occasionally attain four feet. Their local value is very great from the scarcity of wood, and we are told in one place of a seam of from ten to fourteen inches which is wrought, the coal being sold at the mine for twenty cents a bushel. In regions where the product commands so high a price even small seams are precious. The coal deposits of Lincoln county in the eastern part of the state, belong, unlike those just referred to, to the central or Illinois field, and present the unusual character of detached basins of coal, sometimes twenty-five feet in thickness, with little or none of the usually accompanying strata, occupying depressions or previously excavated basins in the Lower Carboniferous limestone. These basins are very limited in extent, and have but a local importance.

The discussions of the various points with regard to the economic geology of the state, the chemical investigation of its iron ores, and the valuable appendix or investigations on the strength of building materials, all of which show good and thorough work alike for science and for the material advancement of the state, would occupy too much of our space. Since the regretted resignation of Prof. Pumpelly, on account of ill health, the direction of the survey has been confided to Mr. Brodhead, whose report for 1873, we have just received and shall soon notice. The beautiful atlas of maps which accompanies the report of 1872 should not pass unnoticed. These maps are from the establishment of Mr. Julius Bien of New York, who, by the admirable style of his work, has put all students of geology and geography under obligations to him. — T. S. H.

Relation of British Wild Flowers to Insects.[1] — The author prefaces his little work with the information that his observations

[1] On British Wild Flowers considered in Relation to Insects. By Sir John Lubbock. Nature Series. With numerous illustrations. London, Macmillan & Co. 12mo. pp. 179. 1875. Price $1.50.

and notes on this subject were originally prepared with the view of encouraging in his children that love of natural history from which he himself had derived so much happiness. A child can readily understand the happy and clear exposition of the subject contained in the pages of this most attractive book. And this is the way natural history should be presented to children. It leads them to take at once a lively interest in the doings of insects and plants, and is worth far more than formal introductions to zoology, just as one can learn more by watching the actions of a live bee or the growth of a plant, than by the inspection of dried specimens.

Children of maturer growth will be startled and set thinking by some of the conclusions of Sprengel, Darwin, Hermann Müller and our author. For example, we are told that to bees and other insects "we owe the beauty of our gardens, the sweetness of our fields. To them flowers are indebted for their scent and colour; nay, for their very existence, in its present form. Not only have the present shape and outlines, the brilliant colours, the sweet scent and the honey of flowers, been gradually developed through the unconscious selection exercised by insects; but the very arrangement of the colours, the circular bands and radiating lines, the form, size and position of the petals, the relative situations of the stamens and pistil, are all arranged with reference to the visits of insects, and in such a manner as to insure the grand object which these visits are destined to effect." The facts tending to substantiate these conclusions are presented by word and picture. We are confident that books like these are destined to revolutionize the study of biology in our schools.

Elements of Magnetism and Electricity.[1] — This compact little manual like the "Principles of Metal Mining," is an English reprint. It is printed with the object of aiding students to pass "in the first class in elementary stage of the government science-examinations." It will be a useful reprint in this country.

BOTANY.

Geographical Distribution of North American Ferns. — An interesting paper on this subject by Mr. J. H. Redfield appears in the Bulletin of the Torrey Botanical Club. The last volume contains an excellent photograph of the late Prof. Torrey.

[1] Elements of Magnetism and Electricity, etc. By John Angell. With 120 illustrations. New York, G. P. Putnam's Sons. 8vo, pp. 176. Price 75 cents. For sale by A. A. Smith & Co., Salem, Mass.

ZOOLOGY.

Flight of Vanessa Antiopa, Feb. 16th.—This afternoon one of our visitors saw a butterfly fluttering in the air. In a few moments it lit on the snow, and he, going to it, found it chilled, and brought it to me. The specimen answers in appearance to *Vanessa Antiopa*. The insect has been flying about a warm room this afternoon.

Considering the intensity of the cold for the past six weeks, and the fact that even to-day the thermometer has not marked 26°, and not a suspicion of dripping even on the south side of the house, I have considered the incident worth relating to you.—E. Lewis Sturtevant, *So. Framingham, Mass., Feb.* 16, 1875.

Snails in Winter.—S. Clessin describes the habits of snails during the winter, their burying in the ground, often in crowds, the formation of the epiphragm, the interruption in the growth of the shell, etc. He thinks that slugs and fresh-water snails are less sensible to the influence of season, hiding themselves later in autumn, and coming forth earlier in spring than Helix and that young specimens are less sensible than older ones. C. B. Ver-Regensb (xxxi, pp. 114–130).—*Zoological Record for* 1872.

Filaria in the House Fly.—Prof. Leidy has recently found that the common house fly is afflicted by a thread worm, about a line in length, which takes up its abode in the proboscis of the fly. From one to three worms occurred in about one fly in five. This parasite was first discovered in the house fly of India, by Carter, who described it under the name of *Filaria muscæ*, and suggested that it might be the source of the Guinea-worm in man.

GEOLOGY AND PALEONTOLOGY.

The Musk Sheep fossil in Silesia.—According to Herr F. Römer, of Breslau, the skull of the musk sheep (*Ovibos moschatus*), the most Arctic herbivorous mammal, has been detected among fossils from the Pleistocene loams of Silesia. The discovery is of some interest, in consequence of the limited occurrence of this species in Germany, three localities only having hitherto yielded its remains.—*Academy.*

A Tertiary Gar Pike in France.—It seems to be proved beyond doubt that a true Lepidosteus lived in the waters of the Paris basin during the early Tertiary period. M. Paul Gervais has recently announced that the ganoid fish from the Paris beds, described by Agassiz as *Lepidotus Maximiliani* should be referred to *Lepidosteus Suessionensis*. This correction is based upon the recent discovery of abundant fish remains, including vertebræ, at Neaufles, near Gisors. — *Academy*.

Fall of Cosmical Dust on the Earth. — It has been ascertained by Nordenskiöld of Stockholm, that small quantities of a cosmical dust, foreign to our planet and containing metallic iron, cobalt, nickel, phosphoric acid, and also a carbonaceous organic matter, falls upon the earth along with snow or rain. — *Amer. Journ. Science*.

ANTHROPOLOGY.

An Indian Mill Seen in the Museum of Nassau, New Providence. — This important object was marked "Indian idol or stool." An image with a human face was carved on the centre of one end of its oval shape; this "stool," as it was marked, was hollowed out, increasing from its two extremities towards the centre, the carved head peering a little above the rim. It was supported by legs, was of wood, the workmanship of the extinct race that once inhabited the island. It was in a good state of preservation, which is no doubt owing to the antiseptic qualities of the air in the cave in which it was found, which preserved the wood, that may be three hundred years old. Many caves have been found in the Bahama Islands which, if they were not the dwellings of the former Indians, must have formed their temporary shelters, as many implements are found in them.

This supposed "stool" was nothing else than a mill; the Indians would not have bestowed so much labor upon a stool. It is, besides, too small for that purpose. The people of the Island possessed in those days tools made of bone or stone, therefore they would only make the articles that manufactured food or clothing, the Islands producing no stone hard enough to be formed into a mill. It is just the height required for a person sitting upon the ground, is much like those made of stone, and in use by the poor

people and Indians of Mexico. I am convinced that this article seen in the museum of Nassau, N. P., was used to bruise or grind the corn, seeds of plants, dried fish, etc., used as food by the ancient and now entirely extinct race. The female sitting upon the ground, takes the mill, places it between her legs; then taking a flat piece of very hard wood (or stone) which can be found upon beaches, she draws it backward and forward, bringing under it whatever is in the mill, which, by rubbing back and forth, is soon reduced to flour, or to any consistency the animal or vegetable substance was desired. — EDWARD PALMER.

MICROSCOPY.

POSTAL MICRO-CABINET CLUB.—A club for the circulation and critical study of microscopic objects has been formed, its design and methods conforming mainly to those of the very successful English club. The following rules have been prepared for the use of the organization, and Rev. A. B. Hervey, No. 10 North Second St., Troy, N. Y., has consented to act as secretary until the first regular election of officers. Applications for membership may be made to him or to the Editors of the NATURALIST.

Rules of the American Postal Micro-cabinet Club.

1. This club shall be called the American Postal Micro-cabinet club.

2. Its object shall be the circulation, study, and discussion of microscopic objects.

3. Reliable persons accustomed to work with the microscope, and able to contribute to the usefulness of the club by sending good objects for examination, shall be eligible to membership.

4. Applications for membership may be made to the secretary, and should be accompanied by reference to some person, preferably a member of the club or a well known microscopist, who is acquainted with the applicant.

5. Names of applicants known to be eligible, shall be submitted to vote by the secretary, who shall send them around through the circuits in the letter packages. A four-fifths vote of all the members shall be necessary to election.

6. Members elect shall be notified of their election as soon as they can be placed in any circuit, either by the formation of new

circuits or by filling vacancies in old ones. They shall then, and during the first week of every January thereafter during their continuance in the club, send to the secretary, as annual dues, the sum of fifty cents. If this subscription should prove insufficient to defray the expenses of the club, the secretary, with the approval of the President and managers, may give notice of an increase to any required sum not exceeding one dollar per year.

7. The officers shall be a President, Secretary, who shall also act as Treasurer, and two managers. They shall be elected by ballot by a plurality of votes cast, blanks for that purpose being sent around by the secretary in January of each year.

8. The secretary shall arrange the members in sections of twelve members each.

9. He shall send a box capable of holding one dozen slides to the first member of each section. Each person shall, within four days of the date of receiving it, put in a slide, preferably one which illustrates some new result of study or method of preparation, and mail the package, carefully directed and stamped, to the name and address next below his own on the list of members of the section. After completing each circuit the box shall be returned to the secretary who shall start it on the next circuit. When it has completed the whole circle of all the circuits, it shall be returned to the first circuit again, when each member shall remove his own slide and replace it with another, mailing the box as before to the next member.

10. Slides placed in the box must contain no writing. Written labels should be soaked off or pasted over, and the slide designated by a number to correspond with the number of the owner in the list of members of the section.

The slides are to be very carefully packed in the box, to which is securely attached by a string, at a distance of two inches, a tag bearing a postage stamp and the address of the next member of the section. Nothing is to be placed around or upon the box which could invite a blow from the post office stamp.

11. If any member should receive a box too much damaged to be safely used, or containing broken or damaged slides, or not containing the full number of slides indicated by the accompanying memoranda, he shall at once notify the secretary and the member who last mailed the box.

If the loss cannot be adjusted by exchange between the owner

of the slide and the person who mailed it, the damaged slide shall be sent to the secretary who shall compensate the owner, to an extent not exceeding one dollar for any one slide, out of any unappropriated funds belonging to the club. Cash on hand and in excess of the estimated expenses of the current year shall alone be considered subject to this claim. Differences of opinion in regard to damages shall be referred to the President, whose decision shall be final.

12. At the same time with the box, and to the same address, shall be invariably mailed a letter-package containing a list of members of the section and of objects in the box, and blank papers for memoranda, remarks, questions and answers, notices of exchanges sought or offered, etc.; also, at the proper times, voting lists for election of officers or the transaction of other business. Everything contained in the letter-package shall be considered the property of the club, shall only be removed therefrom by the secretary and shall be by him filed or published as may seem most advisable.

13. The letter-package and the box of slides should accompany each other, and any member who does not receive either one within three days after the receipt of the other, shall promptly notify the secretary.

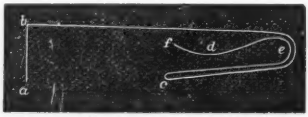
Notice shall always be sent by members to the secretary, one week previously, if practicable, of any change of post-office address, or of any absence from home which would cause more than ten days' delay in the forwarding of any package directed to them.

14. The secretary shall annually submit a detailed statement of receipts and expenditures to the managers, who shall audit the same on behalf of the club.

A NEW SPRING CLAMP FOR MOUNTING OBJECTS.—Mr. Norman N. Mason, of Providence, R. I., has contrived a clamp, or spring clip, for holding the cover-glass in position, which is probably by far the best yet made, both from the ease with which it can be made and the facility with which it can be used. A thin plate of sheet brass or German silver is cut to the shape of fig. 113, and then bent into position as represented in side view by fig. 114. The end of the glass slide is slipped under the spring *d*, and rests against the curve *e*. The point *a*, which may be protected with a

cork if preferred, rests upon the centre of the cover-glass. A little change in the curve of one or both of the plates at *e*, will give any necessary change of pressure upon the slide or the cover. An easy way to form this clamp is to cut strips of the metal as

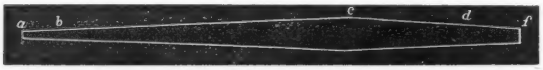
Fig. 113.



Natural size.

long as from *a* to *f*, and as wide as at *c*. One is then bent upon itself at *c*, and hammered down flat; it is then filed, in a vice, with a uniform taper to *a;* the spring *d* is then bent up and the

Fig. 114.



Two-thirds natural size.

curve *e*, formed with a pair of wire-nippers, and finally the long, straight spring turned up at right angles at *b*. Fig. 113 is drawn to natural size; fig. 114 is two-thirds natural size.

Preserving Algæ.—Mr. Thomas Palmer contributes to "Science Gossip" his method of preserving algæ as microscopic specimens. The seaweed is first washed in fresh water, which is left running so as to be continually changed, until the salt is entirely removed. It is then partially dried with blotting paper, and preserved in pure alcohol until wanted for mounting. For mounting it is transferred through chloroform to balsam. This method sacrifices the color, a loss which is overcome by staining with a warm solution of logwood.

Mounting Selected Diatoms.—F. Kitton highly compliments slides received from Herr Weissflog, in which the selected diatoms ("not arranged in patterns, the doing which is a shameful waste of time") are mounted on a thin cover and then inverted over a cell consisting of a thin silver disk, of the same size as the cover, and perforated with a small central opening, often as small as $\frac{1}{50}$ inch. The object in this tiny cell is easily found, stray light is largely cut off, and a very neat mount is produced.

A TINTED CONDENSING LENS.— Prof. E. Abbe, of Jena, whose New Illuminating Apparatus seems not very unlike the common English "Webster Condenser" modified so as to be available in the limited space allowed between the stage and mirror in continental microscopes, suggests the employment as a condensing lens, when lamplight is to be employed, of a large glass globe filled with water colored of a moderate blue tint. This is placed between the flame and the plane mirror below the condenser, and gives, according to the depth of color employed, a nearly white or a decidedly blue illumination.

WIDE ANGLED OBJECTIVES. — Having been a member of the committee of the Memphis Microscopical Society appointed to make certain tests of various object-glasses, it may prove of interest to make public the results of our investigations.

Dr. Carpenter lays down as a fixed law the statement that "all who have made much use of the microscope are now agreed as to the superior value of objectives of moderate or even comparatively small angle of aperture for ordinary working purposes ; the special utility of the very wide apertures being limited to particular classes of objects." (Carpenter, 4th ed., p. 172).

It is now claimed that this no longer holds good; and our investigations were undertaken simply with a view to testing the correctness of this statement.

The glass we selected as the representative of the wide angles was a "four-system" immersion $\frac{1}{10}$th, of nearly 180°; the narrow angles with which it was compared were the best at our command, by leading makers of England, Germany, France and America, and comprised both dry and wet systems. Bearing in mind the theory that the wide angles are only superior on diatoms and with oblique illumination, we discarded diatom tests, and used only central light.

The first slide selected was a specimen of mosquito scales, dry. Under the $\frac{1}{10}$th of nearly 180°, this object was beautifully defined, the structure of the intercostal spaces, longitudinal ribs and terminal spines being all sharply and clearly shown. Even under so high eye-piercing as $\frac{1}{4}$th inch solid (equal to D), the object was splendidly illustrated. The narrow and moderate angles were then successively brought to bear on the same object, with the uniform result that while not giving so good definition under low power

eye-pieces, under the high eye-piece all utterly broke down. The next test selected was a slide of voluntary muscular fibre, in balsam. Here again the nearly 180° glass gave splendid results, the definition of the striæ being perfect even under D eye-piece. The moderate angles were again brought on the field, with the same result as before.

These facts seem to justify the claim that the law, as laid down, touching the general usefulness of the wide-angled glasses, is not now correct, having obtained credence at a period when the difficulties attending their construction had not been thoroughly mastered; but that such is no longer the case. I feel sure that the advanced workers of this country already accept as true the conclusions arrived at by our committee; but I am also sure that by far the greater number of our microscopists still hold to the old faith. — ALBERT F. DOD, *Memphis, Feb.*, 1875.

FREEZING APPLIED TO HISTOLOGY. — Messrs. Key and Retzius, while admitting the value of freezing as a means of hardening certain tissues for cutting sections, have lately called attention to the false canals which are often formed and which not only disorganize the tissue, but might be mistaken for normal structures. At the moment of freezing, the water separates from the tissues and branches out into acicular columns of ice; and the cavities thus formed may be preserved and demonstrated by hardening the frozen sections by alcohol or osmic acid, before thawing them. Exactly similar appearances may be observed in sections of frozen blood or starchy or gelatinous mixtures.

Mr. Lawson Tait, of Birmingham, has found sections of tissue, which were cut while hardened by freezing, to be full of air-bubbles which even the air-pump failed to remove. The contained water had, in freezing, expelled the air it had held in solution, and the bubbles thus produced were so entangled in the tissue as to defy mechanical treatment. They were readily re-dissolved, however, by soaking the section in cold distilled water which had been recently boiled to expel its supply of air.

EMBEDDING IN ELDER PITH. — Dr. C. H. Golding Bird, in a paper read before the Medical Microscopical Society, advocates elder pith as an almost universally preferable medium for embedding tissues preparatory to cutting sections. For holding in the hand it will in most cases give as good results, as the troublesome

wax method, and in far less time; while for use in the microtome it is preferable because of its simplicity and portability, no accessory appliances being required, because it cannot revolve in the microtome like wax, and because of the facility with which it can be removed from the tube and readjusted in it if required. The object, such as a piece of hardened tissue, is loosely packed in the tube of the microtome by means of dry elder pith which, being wetted, in about three minutes swells so as to fill up the vacant spaces and fixes the object immovably in place. This process which is represented as equal, in most cases, to the common method by wax or paraffine, is invaluable for cutting sections of leaves and the like, for which the usual embedding media are nearly useless. Even tissues embedded in wax may be conveniently packed in the microtome by means of pith.

NOTES.

An organization bearing the title of the "Central Ohio Scientific Association" was formed in Urbana, Champaign Co., O., in November last, with the following officers for the present year: President, Rev. Theo. N. Glover; Vice-President, P. R. Bennett, Jr.; Corresponding Secretary and Curator, Thos. F. Moses, M. D.; Recording Secretary, Wm. F. Leahy; Treasurer, J. F. Meyer.

The 22d of November, the block of granite which is designed to cover the tomb of the naturalist Agassiz, left Interlaken for Neuchâtel. It has been taken from the rocks situated below the glaciers of the Aar, near the hut where Agassiz and his colleagues in science explored the glaciers.—*Swiss paper.*

The Detroit "Scientific Association" has during the past winter held monthly meetings. The museum of the society is temporarily located in rooms. The officers for 1874–5 are G. P. Andrews, M.D., President; and A. B. Lyons, M.D., Secretary and Cabinet keeper. There are eight Curators.

The Geological Magazine edited by Henry Woodman, has just completed the first volume of the second decade since its first publication. This journal is of sufficient general and popular interest to secure subscribers in this country among geologists. The publishers are Messrs. Trübner & Co., of London. Subscriptions will also be taken at the Naturalists' Agency.

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